The MagPi

The official Raspberry Pi magazine

Issue 50 October 2016

raspberrypi.org/magpi

50 GREATEST RASPBERRY PI PROJECTS

The definitive countdown of the most inspirational builds ever

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WELCOME TO OUR SPECIAL 50TH ISSUE!

When I was planning the relaunch of *The MagPi* as the official Raspberry Pi magazine some 20 issues ago, I was determined that the community should remain very much at the heart of the magazine. One of the earliest regular features we settled on in this regard was the Project Showcase, which was designed to highlight some of the most impressive projects and their makers. Over the last 18 months, the Project Showcase section has become a firm favourite with readers, so it made sense for us to celebrate our 50th issue with a countdown of 50 of the greatest Raspberry Pi projects ever made.

You've been voting in your thousands to help us decide the running order for the business end of our feature, and we've got some added glitz and glamour courtesy of special guest judges Liz and Eben Upton and Philip Colligan, CEO of the Raspberry Pi Foundation, among others.

So grab some refreshments, find a comfy seat, and strap in for the countdown you've all been waiting for!

Enjoy our 50th issue.

Russell Barnes
Managing Editor

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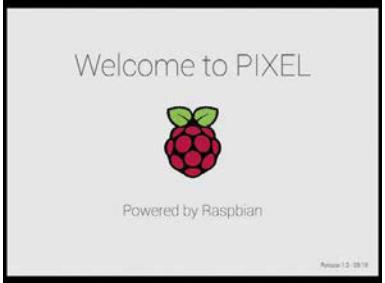

The new Raspbian interface, as created by the Raspberry Pi Foundation boffins

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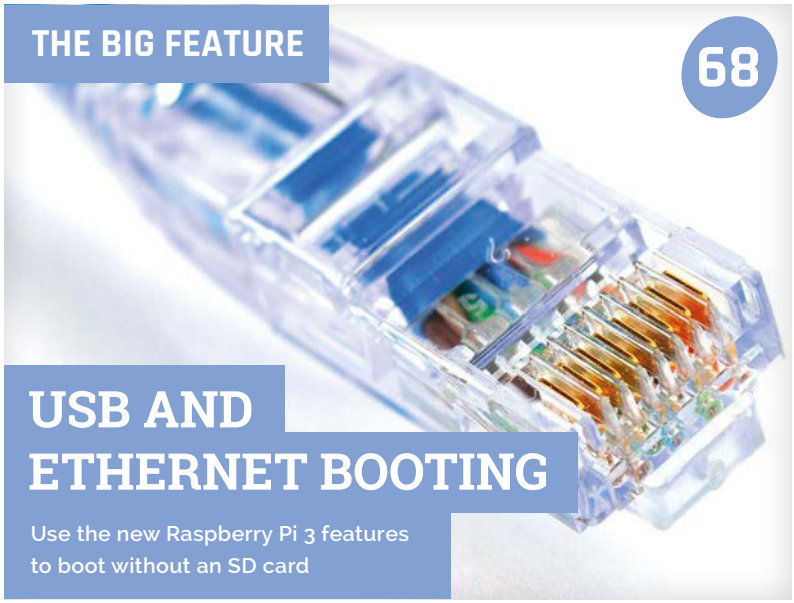

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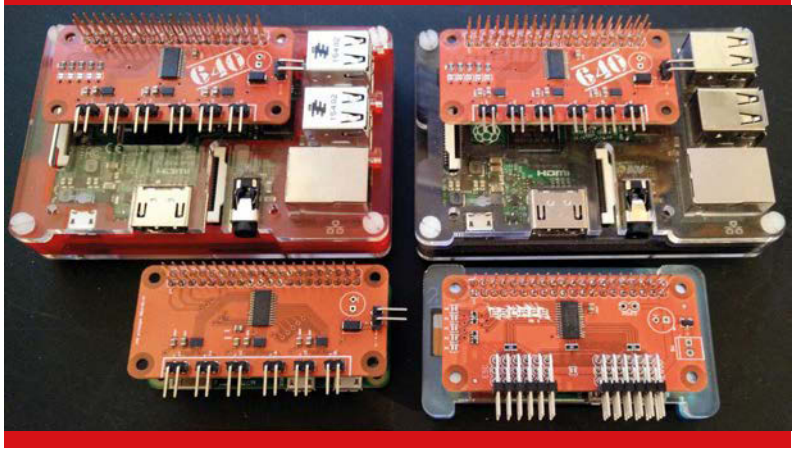

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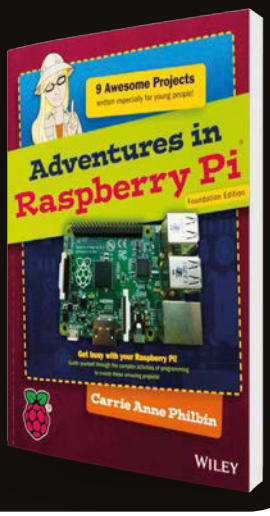
THE OFFICIAL RASPBERRY PI STARTER KIT

Introducing the very first official starter kit for the Raspberry Pi

Above Everything you need to get started with your Raspberry Pi

ADVENTURES IN RASPBERRY PI

The Raspberry Pi Starter Kit comes with Carrie Anne Philbin's *Adventures in Raspberry Pi* book to help get you coding with your brand new Raspberry Pi. It comes with nine projects that teach you how to 'talk to' your Raspberry Pi, create games and stories with Scratch, program turtles with Python, and create a Raspberry Pi jukebox. It's written for 11- to 15-year-olds, but if you're a bigger kid you might be able to get something out of it if you're starting out as well.



The Raspberry Pi has been around for four and a half years now, and yet it's only fairly recently that there have been official accessories for it such as the case and the WiFi adapter. However, that's all changing now with the announcement of the Raspberry Pi Starter Kit, a complete set of bits and pieces to get your new computer going without hunting down a USB mouse in your spare parts box.

The starter kit has been described as "unashamedly premium" by Eben. It includes official accessories where there are some, such as the case, while everything that's not official is the best version that could be found.

The kit was announced alongside the revelation that ten million Raspberry Pis had been sold – you can read more about that on page 10 – and is available to buy right now for £99 from Element14 (**magpi.cc/2cCT8pk**) and RS Components (**magpi.cc/2cCUalq**). We can vouch for the quality of many of the items in the kit (we do especially love the official case), and it could be the ultimate stocking stuffer for a code-inquisitive kid come Christmas in only a couple of months' time.

IN THE BOX

- A Raspberry Pi 3 Model B
- An 8GB NOOBS micro SD card
- An official case
- An official 2.5A multi-region power supply
- An official 1m HDMI cable
- Official optical mouse and keyboard with high-quality scissor-switch action
- A copy of *Adventures in Raspberry Pi* Foundation Edition

AFFORDABLE STORAGE SOLUTIONS FOR RASPBERRY PI

NEW WD PiDrive 250GB Foundation Edition

WD PiDrive 1TB Kit

Accessories

WDLabs is the innovation arm of Western Digital, dedicated to exploring new and emerging technologies around the globe. With specially-designed drives, enclosures and cables for Pi users, WDLabs offers solutions to help you add mass storage to your Raspberry Pi and neatly organize your projects. Visit our website to learn more!

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HEARTFELT TECHNOLOGY HELPS HEART FAILURE PATIENTS

The new Pi-powered medical device watches your feet to see whether or not you need medical care

"Heart failure costs the NHS about two billion pounds per year," reads the Heartfelt Technologies website. Heartfelt is a startup company with a new piece of medical equipment that hopes to reduce this cost drastically, and it's all powered by a Raspberry Pi.

Apparently, one in five people will suffer from heart failure and it's the most common cause of hospitalisation for people aged over 65. What costs the NHS so much money is that half of these people will regularly require emergency visits; however, many of these (about 75%) could be avoided altogether if patients would report the symptoms leading to a visit.

The Heartfelt device watches patients' feet as they get out of bed in the morning, to detect if there's any change in swelling or abnormal cardiovascular activity. It's that simple, and the device could save the NHS a whole lot of money.

Powering the device are seven Raspberry Pis and seven cameras, attached to heavily modified face recognition software that now looks for feet. Any changes that meet a certain set of parameters notifies the relevant medical professionals to allow for treatment with a cheap pill that can sort out any issues before a hospital visit is needed.

It's been through medical trials already and has a CE mark, with first orders having been made in August of this year. Patients who have been tested with it don't mind people seeing their feet, it seems, but they would prefer a nice wood finish on the box to match their decor. Read more at **hftech.org**.

CASE STUDY

Here's a report from a study made with the device in a Cambridge care home with a 75-year-old patient:

"She thought that the idea was good, and that it didn't appear too intrusive. However, she had two concerns: the first one is that the system would take X-rays and she has heard that this may be bad for her health. [When] explained that this was like a video camera taking images, she was perfectly happy with that. The other concern was that the device had an aluminium front to it, and she didn't like the look of it at all, as it wouldn't look nice in her room. She would prefer a wood panel or even a nice flower pattern. She had no concerns about a camera being installed to look at her feet, as she said that living in a care home, carers come in and out of the room quite a lot, so she doesn't feel that this is a privacy issue. If this had helped her to stay home longer, she would definitely have installed this, as she doesn't like being in a care home."

A simple-looking device that sits low on your wall to make sure you don't need to go to the hospital

NUGENIUS

RASPBERRY PI-POWERED DNA IMAGING

The world's first DNA gel imager that's powered by Raspberry Pi

The Heartfelt monitor isn't the only medical device powered by Pi this month: there's also the Syngene NuGenius, which promises to be an affordable DNA image analyser that could help detect genes that cause certain diseases. Here's some of the important info:

"Complete with a high-resolution 5MP camera, UV filter, and integrated Raspberry Pi computer, the compact NuGenius is the perfect choice for quick, accurate DNA imaging. Featuring a touchscreen controlled by image capture software, the system is simple for both students and experienced scientists alike; they can set up and rapidly generate images of fluorescently labelled gel types commonly used to detect genetic defects, and genes that cause diseases such as cancer."

The benefit of using a Raspberry Pi in the device is that it doesn't need to connect to an external computer, with the system able to offer annotation and editing features. Images can easily be saved for a more detailed analysis on another computer, though.

"To our delight, we found that the processor is so powerful that it could easily run all the applications for imaging a DNA gel," says Dr Lindsey Kirby, product manager at Syngene, about why they used the Raspberry Pi. "We then did some hardware and software redesign around the Raspberry Pi and produced the exciting NuGenius imager, which is simple enough for even schoolchildren to use."

> "The processor is so powerful that it could easily run all the applications"

To find out more about the NuGenius, check out the Syngene site for detailed information: **magpi.cc/2cBughI**.

ESSENTIAL SPECS

- **Camera:** 5 million pixels
- **Bit depth:** 12/16-bit
- **Lens:** 8-48mm f1.2
- **Display:** 7" touchscreen
- **GeneTools analysis:** Yes
- **Dimensions:** 75×31×45cm
- **Dynamic range:** 3.6/4.8 (extended)
- **Slim transilluminator 20×24cm:** Optional extra
- **Blue converter screen 21×26cm:** Optional extra
- **Visible light converter:** Optional extra
- **White epi:** Optional extra
- **GeneDirector:** Optional extra
- **Sensor:** 1/2.5 inch
- **Greyscale:** 0-65,536
- **Viewing area:** 20×24cm
- **Image capture:** Yes
- **Weight:** 20kg

Right The complete device, able to take high-resolution images of DNA gel

10 MILLION RASPBERRY PIS SOLD

Shortly after becoming the bestselling British computer of all time, Raspberry Pi hits another incredible milestone

COMPUTER SALES RECORDS

Where does the Raspberry Pi rank in the history of personal computers?

BBC Micro
1.5 MILLION

ZX Spectrum
5 MILLION

Amstrad PCW
8 MILLION

Raspberry Pi
10 MILLION

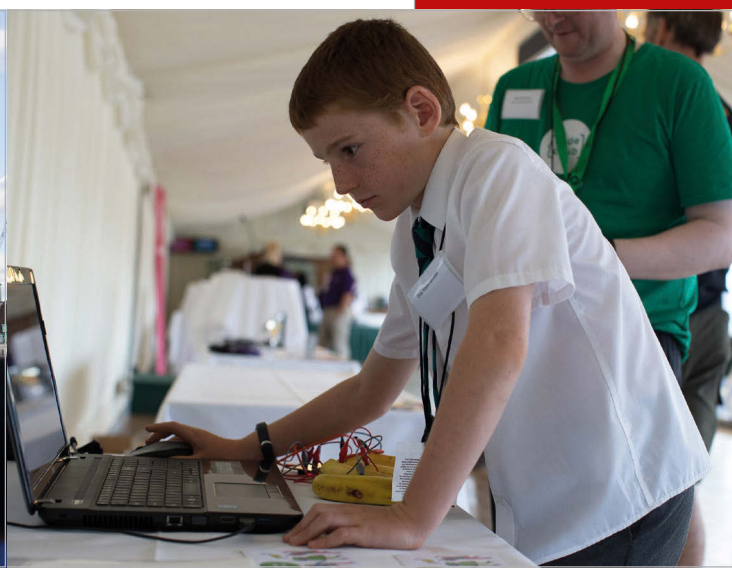
Commodore 64
17 MILLION

On 8 September, Eben Upton revealed in a blog on the Raspberry Pi website that the Raspberry Pi had crossed the ten million sales line. This amazing achievement comes only a few months after the Raspberry Pi 3 launch, where it was revealed the Pi had become the bestselling British computer of all time after selling more than eight million units.

A small celebration was held at the Palace of Westminster, more commonly known as the Houses of Parliament, at the invitation of the Right Honourable Matthew Hancock MP. Matthew is the Minister of State for Digital and Culture, and is responsible for digital policy. Members of the Raspberry Pi community, the press, and Raspberry Pi staff convened at the Terrace Pavilion for a wonderfully unique view of London. There were a few projects on show as well, including a display from *The MagPi* regulars the Hayler-Goodalls.

"As we gather to celebrate the ten millionth Raspberry Pi, it's worth taking a moment to remember how far and fast we've come," stated Eben in a speech given at the event, "and to consider what conclusions we can draw from the success of Raspberry Pi as a product and an organisation. Because at heart, the Raspberry Pi story is one of collaboration: between individuals, within and between organisations,

Eben gave a speech detailing all the amazing things that have happened over the last four and a half years



and within and between clusters.

"When we started Raspberry Pi, we had an almost comically modest ambition: simply to reverse the decline in the number of people applying to study computer science at the University of Cambridge... At the time, there was no expectation that adults would use Raspberry Pi, no expectation of commercial success, and certainly no expectation that four years later we would be manufacturing the vast majority of our products in the UK, and exporting over 80% of our production to the US, continental Europe, and beyond."

Eben went on to detail some of the other extraordinary achievements that have happened thanks to Raspberry Pi, including the changes in the computer science curriculum, and finished off by saying how the initial goal had been achieved: more students are applying to study computer science at university.

The Raspberry Pi's mission is ongoing, and this is only the beginning. Let's see what can be accomplished over the next ten million sales.

Above *The MagPi* contributor Ozzy Hayler-Goodall was on hand to show off some Pi projects

Above left Celebrating ten million Raspberry Pis with a splendid view of London

AFFORDABLE STORAGE FOR RASPBERRY PI. SPACE TO CREATE.

WD PiDrives

With quick and easy storage for your Raspberry Pi projects, the WD PiDrive 1TB Kit and the NEW WD PiDrive 250GB Foundation Edition from WDLabs give you affordable solutions to create storage hungry projects like a media center, surveillance server and more!

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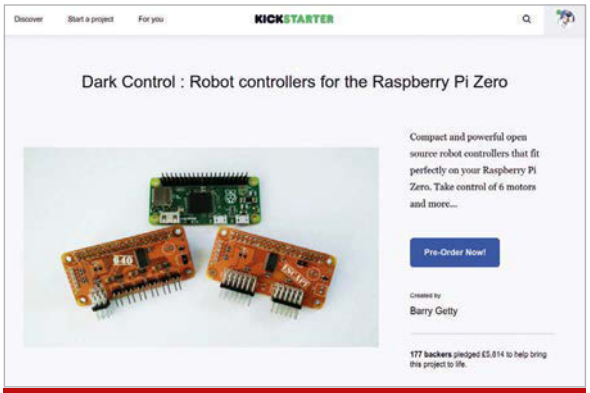
DARK CONTROL FOR RASPBERRY PI

The Dark Water Foundation's latest Raspberry Pi add-on boards promise to make a splash in the field of remotely operated vehicles

"We're trying to encourage people to do underwater robotics rather than on land," Barry Getty explained of the not-for-profit Dark Water Foundation, during a workshop at the Liverpool MakeFest event back in 2015. He was standing in front of a filled fish tank that attendees would be using to test out their LEGO-based remotely operated vehicles (ROVs). "It's a guerrilla attempt to get people to do underwater robotics instead of surface robotics."


Discover
Start a project
For you
KICKSTARTER
Dark Control : Robot controllers for the Raspberry Pi Zero
Compact and powerful open source robot controllers that fit perfectly on your Raspberry Pi Zero. Take control of 6 motors and more...
Pre-Order Now!
Barry Getty
177 backers pledged £5,614 to help bring this project to life.

WHY KICKSTARTER?

"We originally weren't going to make any more boards than we needed ourselves," Barry reveals. "The positive feedback and comments made us think there was an interest in the boards outside of our own plans; so I took some time to tidy up the boards to make them a bit more presentable, and look at what was needed to get them ready to sell and make them easier to manufacture and assemble.

"At this point I thought that Kickstarter wasn't for us. We needed quite a large initial order and the average Raspberry Pi-based Kickstarter campaign was a lot lower than our target would be. I listened to a lot of people and decided to take a chance: we spent two weeks getting the campaign ready, took a holiday, and then released."

A year later, Barry's passion for underwater robotics hasn't dimmed, but the technology behind Dark Water has shifted. Where the original boards were Arduino-compatible, a desire for increased capabilities called for boards with more power.

Switching to the Pi Zero

"We had been looking for something that was small enough to fit inside a waterproof pressure container and be sent underwater. The larger the board, the wider the container required, but when you factor in potential pressures at depth, you also needed thicker walls to handle that and keep the water out," Barry explains of his team's progression in the year since our last interview. "The OpenROV team were using the BeagleBone Black, but we wanted to make a much smaller ROV or even a container that could be fitted to a slightly larger version of our LEGO ROV body.

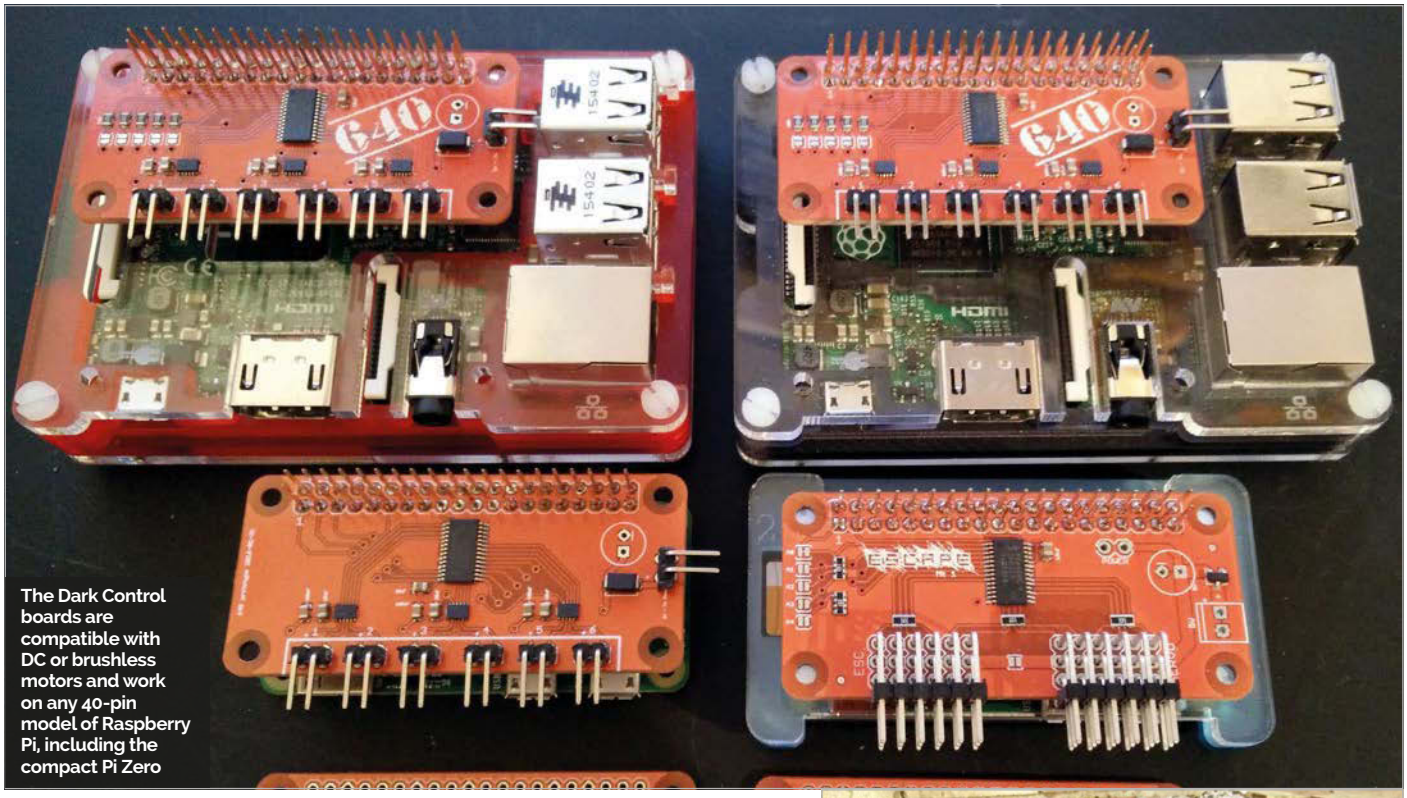
"The small size of the Pi Zero removed a lot of these issues," he continues. "We could now fit an extremely capable Linux computer in a very small and cheap container. We just needed motor drivers that were the same size to fit on it."

Although motor driver boards for the Raspberry Pi are nothing new, Barry and his team needed something which didn't exist elsewhere: six-motor capability. "For ground and flying robots, those extra motors maybe aren't that big a deal, but for underwater robots six motors adds so much more," Barry enthuses. "Six motors on an ROV means you can have four motors, full vectored thrust for horizontal manoeuvrability, and two vertical motors for depth and tilt. For an underwater bottom-crawler, you can get full four-wheel drive and an extra two motors to control stabilisation and lift.

"For DC motors there aren't any other boards available, Pi Zero-sized or not, that are capable of running that many motors with a single board. For brushless motors, we looked at the annoyances we found with other boards and autopilots and tried to get rid of them. The main niggle we hated was having to remove or cut the power cable from the ESC [electronic speed control] connectors on all but one of the ESCs."

Dark Control is born

With nothing available on the market, Barry and his team turned to their experience in circuit design and came up with two boards that proved a perfect fit. The Dark Control 640 works with DC motors, and the Dark Control Escape with brushless motors. Still, though, the team's work wasn't done.



The Dark Control boards are compatible with DC or brushless motors and work on any 40-pin model of Raspberry Pi, including the compact Pi Zero

"Then we looked at controlling robots," Barry recalls. "Most Raspberry Pi robots are controlled via WiFi or Bluetooth; some even use infrared remote controls. All of these have range issues, especially when used outside. No one, it seemed, had thought of a board this cheap allowing a radio control receiver to be plugged into it to take advantage of the extended range. It turned out we could implement CPPM [Combined Pulse Position Modulation] reasonably easily and with very little extra work / components – so we did. Then we thought, 'We still have some space on here – let's add things!' So we added extra PWM [pulse-width modulation] servo headers to each board."

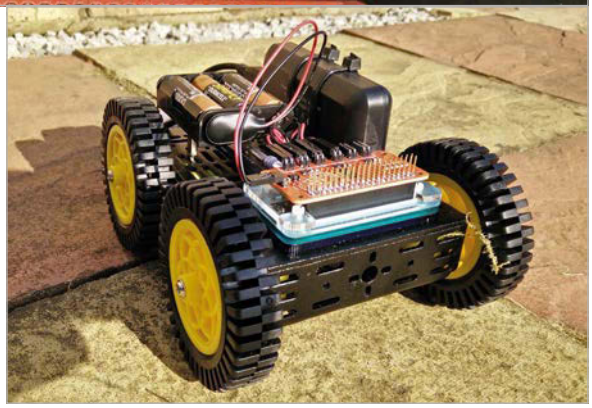
Barry's team had added yet more capabilities to the design by the close of the Kickstarter campaign. A nine degrees of freedom (9DOF) inertial measurement unit (IMU) extension board is now complete, and it's possible to add sensors ranging from barometers suitable for aircraft use to air quality systems for data gathering.

It's a mixture found nowhere else, and one that has captured plenty of attention. The Dark Control crowdfunding campaign closed with 145 percent of its modest £4,000 goal raised, and deliveries of the boards have already begun.

> "The Dark Control crowdfunding campaign closed with 145% of its modest £4,000 goal raised"

For Barry, though, the excitement is only building. "If we can encourage people to send their robots off into the world to explore, and to publish the data they find, then the world will be a better place. If we can provide tools that are small and capable enough for people to fit into underwater robots, then we're heading in the right direction."

More information on the project can be found at **darkwater.io**.



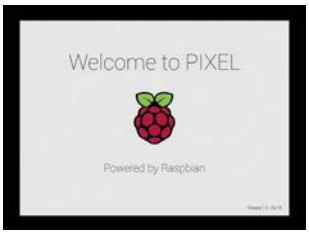
Above Although built with underwater exploration in mind, the Dark Control boards are equally at home on land or in the air

GETTING STARTED

"For a beginner I'd recommend putting a board on a Raspberry Pi 3," Barry explains of his Dark Control add-ons. "It has more USB ports for WiFi, a keyboard and so on to be added, so they can get programming a lot easier. Once they have working code, then put it on a Pi Zero to reduce the size of the robot. The less space taken up by the processor, the bigger the motors you can fit!

"Our aim is to encourage people to think outside of building hobby robots. If you can build a robot capable of driving around your living room, then you can build something with an air quality sensor that can drive around a field. Think outside of your living room, and try to think of how your skills can help your community."

INTRODUCING PIXEL



The Raspberry Pi Foundation releases a stunning new desktop fizzing with features

Raspbian is getting its biggest update ever this month, thanks to a dazzling new desktop environment called PIXEL.

Raspbian with PIXEL (which stands for 'Pi Improved Xwindow Environment, Lightweight') is a huge software update to the desktop environment. It introduces a crisp new interface, and is brimming with new programs and features.

The biggest newcomer is Chromium Browser, which replaces Epiphany as the default web browser. Other new apps include RealVNC's Viewer and Server, which allow you to control Raspberry Pi devices over a network, plus the recently released Sense HAT Emulator.

But the real star isn't the new apps: it's the sensational new look.

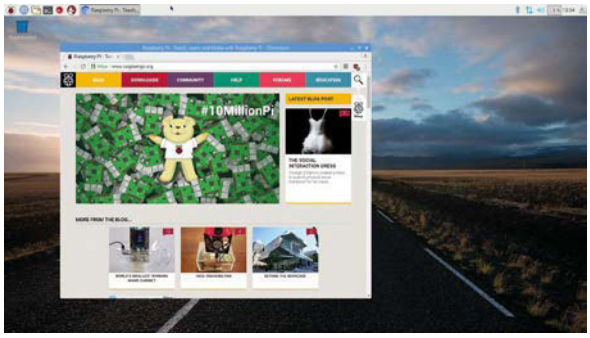
Baking a better Pi

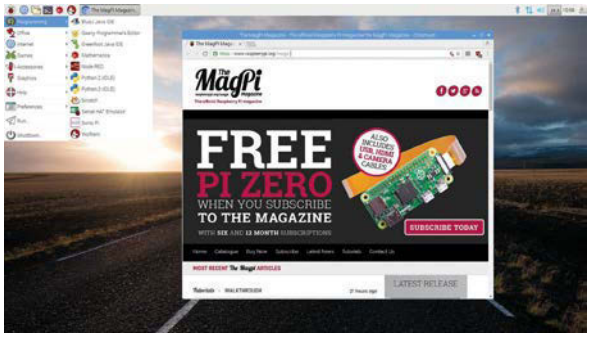
Simon Long, UX engineer at Raspberry Pi, told us the story behind Raspbian with PIXEL: "It was just over two years ago when I walked into Pi Towers for the first time. On the first day, Eben and I sat down and played with the Raspbian desktop for half an hour. He asked me 'do you think you can make it better?'"

That conversation led to two years of hard work building a new interface. You'll notice the difference as soon as you boot up your Raspberry Pi. Instead of viewing text scrolling up the screen, Raspbian with PIXEL starts with a boot splash image.

The splash screen is followed by a stunning photograph of an Icelandic road on your desktop. "We are very fortunate in

Below Chromium is now the default web browser in Raspbian with PIXEL





Above Raspbian with PIXEL introduces a whole new interface with a much more professional look

UPDATING TO RASPBIAN WITH PIXEL

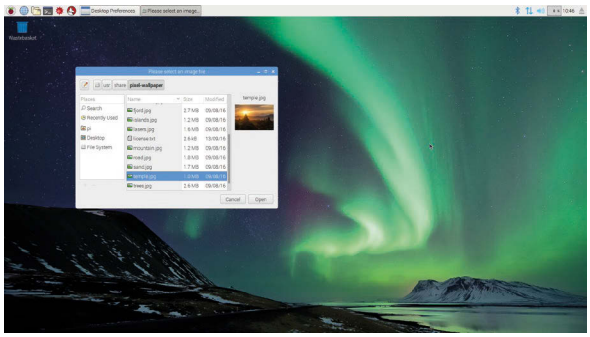
The PIXEL desktop ships with the new Raspbian image file. Raspbian with PIXEL is available at the Raspberry Pi downloads page: **raspberrypi.org/downloads**. It's also possible to update a current Raspbian Jessie installation using these commands:

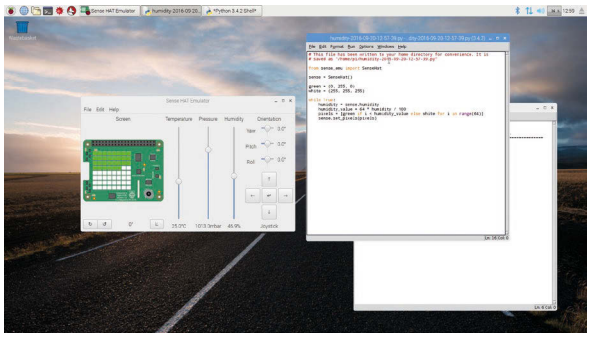
```
sudo apt-get update
sudo apt-get dist-upgrade
sudo apt-get install -y rpi-chromium-mods
sudo apt-get install -y python-sense-emu python3-sense-emu
        python-sense-emu-doc
```

Please note that if you already use xrdp to remotely access your Raspberry Pi, this conflicts with the RealVNC server, so you shouldn't install both at once. If you don't use xrdp and would like to use the RealVNC remote access packages, enter this line:

```
sudo apt-get install -y realvnc-vnc-server realvnc-vnc-viewer
```

Reboot to use Raspbian with PIXEL.





Far left PIXEL comes packed with beautiful photography options for the desktop wallpaper

Left Code designed for the Sense HAT can now be tested using a built-in emulator

that Greg Annandale, one of the Foundation's developers, is also a very talented (and very well-travelled) photographer, and he has kindly allowed us to use some of his work as desktop pictures for PIXEL," explains Simon.

The making of an icon

The visual refresh extends far beyond the desktop imagery. The icon set has been completely redesigned with a much friendlier feel, in keeping with the Raspberry Pi website.

"Sam Alder and Alex Carter, the guys responsible for all the cartoons and graphics you see on our website, have been sweating blood over these for the last few months," remarks Simon, "with Eben providing a watchful eye to make sure every pixel was exactly the right colour."

"The old window design looked a bit dated, compared to what Apple and Microsoft are shipping, says Simon. "[PIXEL] windows now have a subtle curve on the corners, a cleaner title bar with new Close, Minimise, and Maximise icons, and a much thinner frame."

PIXEL perfect

Closer inspection of Raspbian with PIXEL reveals further features. "In the past, if your Raspberry Pi was working particularly hard, you might have noticed yellow and red squares appearing in the top-right corner of the screen," says Simon. "These have been replaced with new symbols that make it a bit more obvious: a lightning bolt for undervoltage and a thermometer for overtemperature."

You can also disable WiFi and Bluetooth from the menu bar, a frequently requested feature.

PI CAN BE MESSY.
BUT IT DOESN'T
HAVE TO BE.

With a wide range of cables and enclosures for your Raspberry Pi projects and the WD PiDrive, WDLabs helps keep your creations properly powered and organized.

WDLabs Raspberry Pi Accessories

WDLABS
wdlabs.wd.com

THE 50 GREATEST RASPBERRY PI PROJECTS

MEET THE JUDGES

Celebrate **50 issues of The MagPi** with incredible projects that change what you think is possible

The Raspberry Pi has been used to build incredible things, from real-life magic mirrors to hybrid electric racing cars. Not a day goes by without an amazing new project.

While there's still a core mission of education, the Raspberry Pi is so customisable that makers immediately started using it to create the projects of their wildest dreams. And they never stopped.

It wasn't easy. But working together, we collected the 50 most inspirational projects in a celebration of everything Raspberry Pi.

We could have easily added another 50 jaw-droppers, but with the community's help to choose the top 20, we have an excellent mix of fan favourites and professional picks.

So without further ado, here's the 50 Greatest Raspberry Pi Projects ever made...

EBEN UPTON
CEO, Raspberry Pi Trading

Software Projects judge

PHILIP COLLIGAN
CEO, Raspberry Pi Foundation

Projects for Good judge

LIZ UPTON
Director of Communications, Raspberry Pi Trading

Young Makers judge

MICHAEL HORNE
Web developer

Robot Projects judge

TIM RICHARDSON
Performance architect

Robot Projects judge

And not forgetting...

THE RASPBERRY PI COMMUNITY (YOU!)

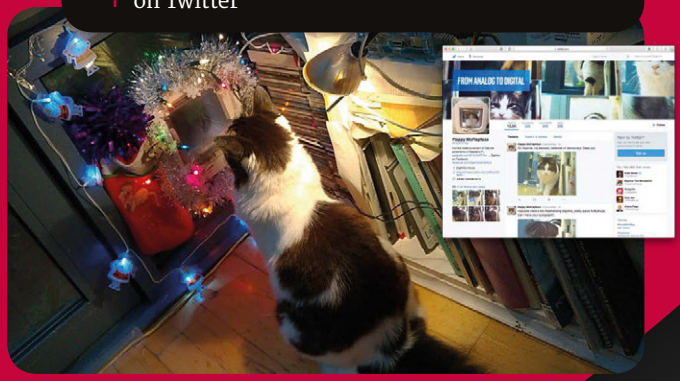
Top 20 judges

FLAPPY MCFLAPFACE

30

CREATED BY: Bernie Sumption
URL: magpi.cc/1VKui85

FAST FACT:
This tweeting cat flap has over 840 followers on Twitter



All cats think they're special, but only Daphne has her very own Twitter-enabled cat flap that heralds her arrival online. The Flappy McFlapface project snaps a photo and tweets it, along with a cute randomised phrase.

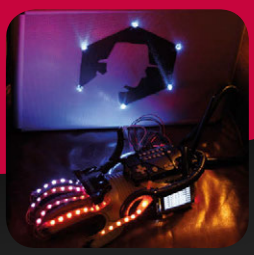
Built by Bernie Sumption, this cat flap is a thing of beauty. "Daphne often takes to social media to rant about the inadequate service provided by her staff (technology journalist Kate Bevan)," explains Bernie on his blog – **magpi.cc/1VKui85**. "This activity is cathartic and highly recommended for any household pet. You can follow Flappy McFlapface on **@DaphneFlap.**

MAKER SAYS "Daphne often takes to social media to rant about the inadequate service provided by her staff"

29

CREATED BY: Cory Kennedy
Family man and cyber-defence specialist
URL: magpi.cc/2cJUYbr

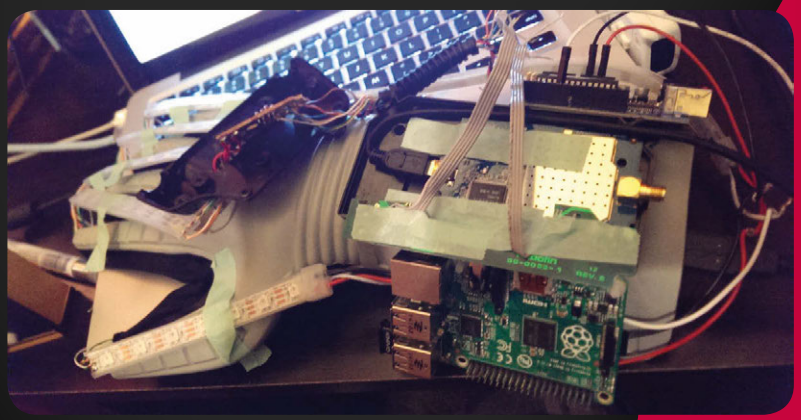
FAST FACT:
It only took about a week to build



PWNGLOVE

Nintendo's Power Glove was an infamous NES peripheral that has been the butt of many jokes, and the centre of a lot of nostalgia. The Power Glove didn't live up to its original promise, but Cory Kennedy decided that the Raspberry Pi could change all that. "I wanted to do something different," says Cory. "I wanted to be the kid from the 'Now you're playing with power' ad."

There are four original bend sensors (thumb, index, middle, and ring), which connect to an analogue multiplexer living in the palm housing, which sends that data back to the Arduino. This is then piped back to the Raspberry Pi over Bluetooth.



28

CREATED BY: Frederick Vandenbosch
URL: magpi.cc/2cJW7Qk

FAST FACT:
The build was part of the Sci-Fi Your Pi competition launched by Element14 and Raspberry Pi

PI DESK

Nobody wants a boring desk, but one hobbyist, Frederick Vandenbosch, went and built this futuristic table complete with a touch surface, speakers, and a motorised display that rises out of the surface. The PiDesk is one of the cleverest projects we've come across.

"The build was part of a design challenge," says Frederick. The Sci-Fi Your Pi competition was launched by the Raspberry Pi Foundation and Element14 to inspire inventors to build smarter homes. "PiDesk is an attempt at making a space-saving, futuristic-looking desk" he explains. "It can change from a regular desk to a computer workstation and back at the touch of a finger."

MAKER SAYS For the project's futuristic accents, I was inspired by the Tron movies, on which I based the light patterns of the desk"

DIGITAL ZOETROPE

27

CREATED BY: Brian Corteil
URL: magpi.cc/2cotnva

FAST FACT:
Since his project uses OLED displays with the Raspberry Pi, it's actually possible to update the frames in real-time, so you could watch an entire film if you wanted

Before the invention of cinema, people used animation devices called 'zoetropes' to produce the illusion of movement.

The Digital Zoetrope replaces the photos on the inside with 12 OLED displays. Despite incorporating a wealth of technology, Brian's Digital Zoetrope is moved by hand. Like the original designs, you spin the device and look through the slats to see movement in the still images as they rotate.

MAKER SAYS "I was inspired by the work of Eadweard Muybridge, an early pioneer of high-speed photography"

SOUND FIGHTER

26

CREATED BY:
Cyril Chapellier & Eric Redon
URL: magpi.cc/2d1CsaT

FAST FACT:
The project was pitched for the reopening of the Maison de la Radio, a historic building in Paris

Cyril Chapellier and Eric Redon brought a new dimension to the phrase "duelling pianos" with this installation.

Sound Fighter turns two pianos into controllers for a game of Street Fighter Alpha 3. "We transformed two classical upright pianos into PlayStation 2 controllers using custom analogue piezo triggers, a Raspberry Pi B+, and Arduino Unos, and created a special Python 3 firmware to map a classical playing style onto the Street Fighter Alpha 3 gameplay," explain the French duo.

PI IN NUMBERS

10 MILLION
Raspberry Pi boards sold

6:1
Raspberry Pi vs BBC Micro

2:1
Raspberry Pi vs Sinclair Spectrum

80% SOLD overseas

20,000 A DAY
built in South Wales

125,000
monthly readers of The MagPi

1 MAGPI
obtained every 20 seconds

3,062 MagPi pages & counting

THE BEST

ROBOT PROJECTS

The Raspberry Pi has helped revolutionise hobby robotics – here are some of the best Pi robots

If there's one thing that we've learnt from running CamJam and Pi Wars, it's that everyone loves a Raspberry Pi-controlled robot. Our first big Jam featured a talk from Matthew Timmons-Brown on robotics in education and, at the last Jam, Brian Corteil talked us through how to build a Pi Wars-winning robot. Whether you're into wheeled buggies, walkers, quadcopters or ROVs, robots are everywhere and the trend looks set to continue. In this section, we choose our top five robots, including one from Pi Wars! So, read on and let us know if you think we've made the right decisions.

JUDGES

Michael Horne and Tim Richardson

CamJam and Pi Wars organisers

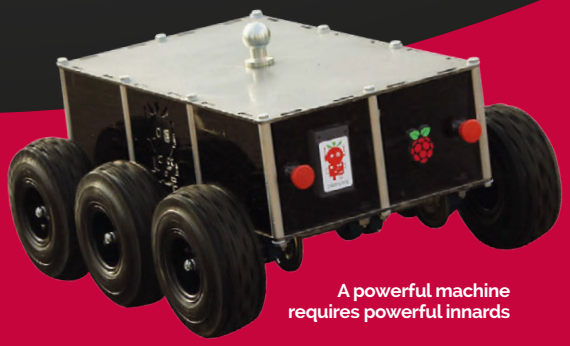
Michael (right) and Tim (left) live with their respective, long-suffering wives and children in Potton, Bedfordshire. Together, they organise the Cambridge Raspberry Jam and Pi Wars, and created the CamJam EduKits.

1

CREATED BY: PiBorg
URL: magpi.cc/2ciYDg1

DOODLEBORG

Billed as the Raspberry Pi tank, this beast of a machine is one of the biggest Raspberry Pi-powered vehicles around. It may be low on horsepower, but it's high on torque, and the trailer hitch allows it to tow a caravan using a PlayStation 3 pad to control it. It's built using PiBorg's motor controllers, and uses the great metallic design you'd expect from a PiBorg build.



A powerful machine requires powerful innards

JUDGES SAY "The monster truck of robots: with a 12V battery, six wheels, and three horsepower, it's strong enough to carry a person!"

2

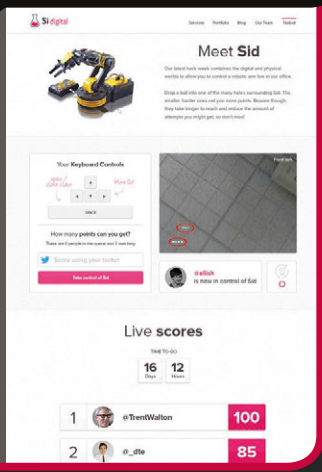
CREATED BY: Si digital
URL: magpi.cc/2cm4ocR

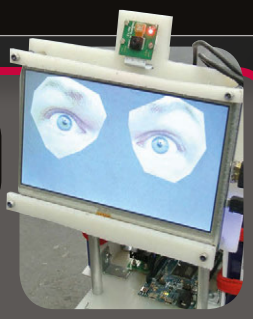
SID THE OFFICE ROBOT

We kind of love the idea of Sid: an internet-controlled robot whirring away in your own office as people play games with it. It would probably get a little annoying after a while, but what a fun few weeks that would be. Apparently, it was so popular at one point that people were waiting four hours to play with Sid! 4chan also tried to break it, but were unsuccessful due to some clever building and coding work.

Sid was operated using a very simple control method

JUDGES SAY "A robot arm with a gamer's attitude, you can control Sid online and drop balls into holes to score points!"





3

CREATED BY: Kris Temmerman
URL: magpi.cc/2cqRCXq

BALANCEBOT

We spoke to Kris about his BalanceBot in issue 42 of the magazine. The BalanceBot's balancing act is very impressive due to how tricky it is. Riding on two wheels isn't its only trick, though: it has facial recognition software attached to a Pi camera, so it can react to the people around it using slightly odd cut-outs of Kris's facial features. It's a work in progress, but what he's managed to do so far has really impressed us!

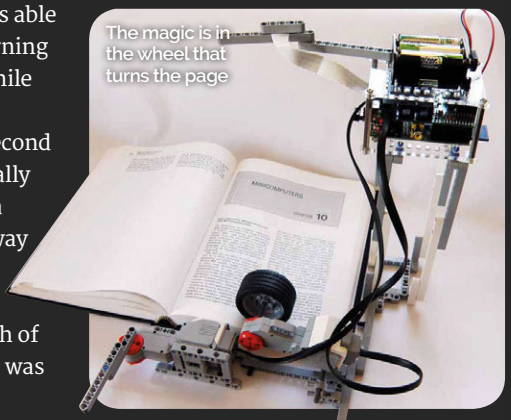
JUDGES SAY "Balancing on two wheels and with a Qt front end, Kris Temmerman's robot uses C code for real-time control"

4

CREATED BY: Dexter Industries
URL: magpi.cc/2crkOxu

BRICKPI BOOKREADER 2

The original Bookreader was able to read books on Kindle, turning the pages with a button. While certainly impressive, it was quickly outclassed by the second Bookreader that could actually read and turn the pages of a physical book. BrickPi is a way for LEGO Mindstorms to hook up to the Raspberry Pi, and with this mish-mash of LEGO and Pi tech, the robot was able to best its predecessor.



JUDGES SAY "Using a mixture of LEGO and OCR with their BrickPi interface board, Dexter Industries have found a way for your Pi to read a real book!"

PI WARS 3!

Have a Raspberry Pi robot that you want to show off in a series of excellent challenges? Feel like you want to build one after seeing these amazing robo-projects? Then you may be interested in Pi Wars 3, which takes place in April 2017. It's organised by Michael and Tim, who judged the robots on this page, and you can find out more details on the Pi Wars website: **piwars.org**

Pi WARS
The Raspberry Pi Robotics Challenge Competition

5

CREATED BY: Tom Oinn
URL: twitter.com/approx_eng

TRIANGULA

"I wanted to build something that wasn't a standard two-wheel or track differential drive," Tom told us when we caught up with him. His triangle-shaped robot with a holonomic drive (it can move in any direction even while rotating) did very well at Pi Wars 2015, with Tom boasting that it was the most agile robot there. No wonder it won Pi Noon. You can read the coding documentation, which Tom is quite proud of, here: **magpi.cc/2cJ7X9S**.

JUDGES SAY "Tom Oinn's laser-cut, hand-tooled triangular robot with lots of blinkies on board impressed at last year's Pi Wars, winning Pi Noon!"

25

CREATED BY: Joseph Hazelwood
URL: magpi.cc/2d8Qcjo

FAST FACT:
It's on display in an old cigar warehouse that used to house 100,000 cigars

#OZWALL

The #OZWall video installation, the brainchild of Joseph Hazelwood, sits in the 'Escaparate', the focal point of Nashville Tennessee's centre for world-class contemporary art, OZ Arts (**ozartsnashville.org**).

"We like to think of this installation as a canvas for other artists to build upon," Joseph tells us, "and that's the beauty of open source and platforms like the Raspberry Pi."

Joseph started by retrofitting six vintage TVs with modern LCD panels. "Each TV is outfitted with its own Raspberry Pi 2. We used the code from the CCFE Pi Wall project (**magpi.cc/2cmigxM**) and tailored it to our needs.

In 2016, the #OZwall was upgraded for interactivity. "The first iteration of this functionality was #OZPodButtons for OZ Arts Fest," says Joseph. "At this event, a visitor was able to push buttons installed on many art pieces in the room to switch video content and get corresponding information."

MAKER SAYS "A visitor to OZ will walk into the Escaparate and be drawn into an interactive multimedia experience"

24

CREATED BY: Jack Chalkley
Head creative technologist at Knit
URL: weareknit.co.uk

FAST FACT:
You can interact with HiutMusic on Twitter **@HiutMusic**

#HIUT MUSIC

The #HiutMusic jukebox is a rather beautiful Twitter-powered music player that takes pride of place in the Hiut Denim Factory on the west coast of Wales, where "the music is loud and the coffee is strong."

It was created by Knit, a creative technology agency that approached Hiut Denim with an idea to help customers connect with the boutique jeans company.

It's powered by an internet-connected Raspberry Pi, which uses the Spotify and Twitter APIs in a rather novel way. "It plugs into the existing sound system on the factory floor and fans can request a track by posting a tweet that includes #HiutMusic, the artist, and track title," says Jack. The tweet is detected and the song is queued up and played."

MAKER SAYS "We wanted to facilitate a dialogue between Hiut and their fans through the emotion of music"

23

CREATED BY: Dave Sharples
URL: davesharpl.es

FAST FACT:
The Joytone was on show at the Toronto International Film Festival and had around 16,000 visitors

JOYTONE

Designed and crafted by engineering expert Dave Sharples, the Joytone is a unique musical instrument played using an array of mini-joysticks.

"I've always wanted to be able to play a musical instrument," says Dave, "and a couple years ago I took a music theory class to see if that could help me learn piano."

According to Dave, Joytone is a unique new musical instrument that features a hexagonal grid of 72 joysticks. "The Joytone's hexagonal grid exposes musical patterns that are normally obscured by the quirks of common acoustic-style interfaces, like the white and black keys of a piano. Each joystick plays one note and the motion of the joystick affects the volume and character of the note," he explains.

MAKER SAYS "I became fascinated with the patterns associated with musical structures and realised how beautifully simple music can be"

PIP-BOY 3000A

22

CREATED BY: Jesse Roe
URL: magpi.cc/2d8QKVW

FAST FACT:
Jesse completed the project between October and Christmas 2014

"The project was an attempt to make a fully functional Pip-Boy 3000A. Not something to stick a phone in, but an actual working device," Jesse tells us, referencing the official Pip-Boy which will require a smartphone.

Having never found a perfect use for his Raspberry Pi, Jesse decided to use it for this project he was making for a friend. Using a 3D-printed case that he modified himself, the build wasn't simple.

"I worked on this probably about 70 hours total, with a lot of that being just research," Jesse explains about his build process. "There was a lot of stuff out there on making a Pip-Boy, where to get the cast from, materials, etc. The main piece to get was the Pip-Boy cast itself, which I ordered from Nakamura Shop on Shapeways."

21

CREATED BY:
Dave Akerman
URL: daveakerman.com

FAST FACT:
The eventual aim is to fly a series of balloons across Europe, with data passing from balloon to balloon

PI IN THE SKY

Dave is a high-altitude ballooning enthusiast who has been tethering Raspberry Pi boards to helium balloons and sending them to the edge of space since 2012. His hobby and choice of computer have been attracting much attention since, leading to a rather hectic life for the software programmer, and helping to show further evidence of the adaptability of the Raspberry Pi.

"The Raspberry Pi had two big effects [on my high altitude ballooning]: the addition of live images and all of the media attention," Dave tell us. "I expected the former, but not the latter. It's all been good, though."

TEAM PICKS

Lucy Hattersley
News Editor

FLAPPY MCFLAPFACE
I love Flappy McFlapface, the tweeting cat flap. Partly because it involves cats and the internet (always a winner). But also because it's an IoT project in disguise. On the surface, you're just making fun of your cat, but look deeper and there is lots of Python code and scripting being used to hook a door up to the internet, and to Twitter. The creative language generator is the icing on the cake. Also, it just works! Follow **@daphneflap** on Twitter and she's still tweeting her mugshot daily.

Phil King
Sub Editor

SEEMORE
Virginia Tech's huge kinetic-sculpture-cum-computing-cluster is a spectacular sight. Not only is it a mesmerising work of art as its articulating arms move in cascading patterns, but it's also a brilliant visualisation of the concept of parallel computing. I particularly like the transparency of the design, with its exposed wiring, enabling everyone to see how it works. Comprising 256 Raspberry Pis and countless custom parts, it's not something you could replicate at home, but it's inspiring nonetheless.

THE BEST SOFTWARE PROJECTS

It's not just about physical builds – Raspberry Pi would be nothing without its amazing software creations...

JUDGE

Eben Upton

CEO of Raspberry Pi (Trading)

Eben is a co-founder of the Raspberry Pi Foundation and serves as CEO of Raspberry Pi (Trading), the Foundation's engineering subsidiary. He likes cats, for some reason.

It's fair to say that we went into Raspberry Pi with some unrealistic ideas about what we could reasonably expect the open-source software community to do for us. It's not enough to put a piece of hardware out there with bare-bones software support and expect volunteers to fix everything for you, for free: many core software tasks need to be handled by an in-house team.

On the other hand, we've been consistently amazed by the wide variety of third-party software that people have developed on top of this core, without which the Raspberry Pi ecosystem would be a much less exciting place. It's hard to pick favourites, but here are a few standout applications.

1 RETROPIE

CREATED BY: RetroPie team
URL: retropie.org.uk

RetroPie has the ability to realise many people's dreams of owning their own custom arcade cabinet, bringing simple-to-use arcade and console emulation to the Raspberry Pi with very little fuss. It even works on the Pi Zero, which enabled us to put a Zero into a NES and SNES controller for the magazine, while still being powerful enough to drive a whole arcade cabinet. Just remember the law about what ROMs you can use, though.

EBEN SAYS "Who doesn't like a trip down memory lane? With an enormous list of supported platforms, you can waste (I prefer to say 'invest') hours reliving your youth. With a Raspberry Pi 3, even many N64 games run smoothly"

2 MINECRAFT PI

CREATED BY: Mojang
URL: magpi.cc/2cu8nkC

Minecraft Pi was originally developed to run on the first-generation Raspberry Pis: it was a little stuttery on them, but since the Raspberry Pi 2 it's been great to use. It's not just a game, though: thanks to the API being open to use, you can modify it with Python and even hack it with other programming languages. Using Python as a bridge to the GPIO pins, you can even have Minecraft interact with the real world...

EBEN SAYS "An early addition to the Raspberry Pi platform back at the tail end of 2012, Minecraft Pi was developed for us as a favour by Mojang. It's a fantastic educational tool: if only we could persuade Microsoft to produce an updated version!"

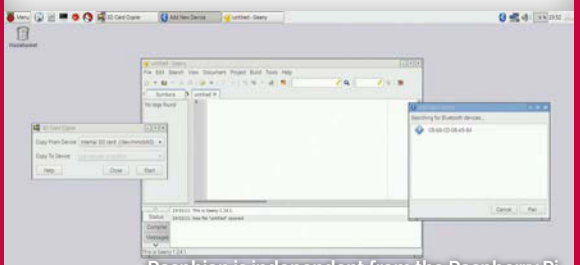
3

CREATED BY: Mike Thompson & Peter Green
URL: raspbian.org

RASPBIAN

Raspbian is ubiquitous with Raspberry Pi. As the premier operating system for the Pi, you'll rarely find a project that uses anything else, and all the tutorials and learning resources on the Raspberry Pi website are built around it. The community have really taken to it and tons of bespoke software has been created or ported to Raspbian to allow for a fantastic user experience. PIXEL may now be here, but it's still Raspbian at the core.

Raspberry Pi + debian = Raspbian



Raspbian is independent from the Raspberry Pi Foundation, but they still do plenty of work on it

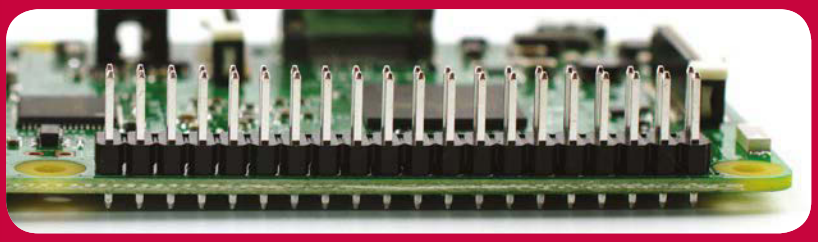
EBEN SAYS "Mike Thompson and Peter Green's painstaking rebuild of hard-float ARMv7 Debian for the ARMv6 processor in the original Raspberry Pi: where would we be without it? Still the backbone of our OS strategy"

4

CREATED BY: Ben Croston
URL: magpi.cc/2cEMDCv

RPI.GPIO

Quite a miraculous Python module, RPi.GPIO opened up the GPIO pins to everyone, with the ability to pretty much directly control what each programmable pin can do. It's become a staple of many tutorials for beginners and veterans alike who just want to light an LED, or even control an entire robot. The great thing is that it works across every version of the Raspberry Pi, as long as you take into account the different number of pins on the first models.



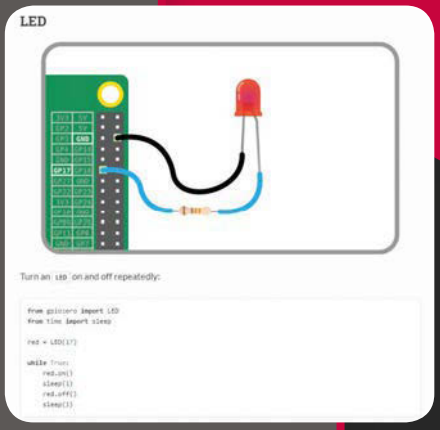
EBEN SAYS "I remember the happiness in the office when this first appeared. Use it via GPIO Zero, or import it directly: Ben Croston's RPi.GPIO remains the canonical way to access the interfacing features of the Raspberry Pi"

5

CREATED BY: Ben Nuttall
URL: magpi.cc/2cqUEhp

GPIO ZERO

RPi.GPIO is amazing, but for newcomers it's not the easiest to use, which is where Ben Nuttall and Dave Jones came in. Enthusiastic to get people setting up and supporting Jams around the country/world, Ben's just as passionate about making the first steps into coding just that little bit easier. Together they've managed that with this excellent library that makes common operations a doddle to write in Python, and which is just about celebrating its first anniversary this issue.



EBEN SAYS "Another entry in the Foo Zero Olympics, after Pygame Zero and before Raspberry Pi Zero. Ben Nuttall's done a cracking job of stripping the boilerplate out of Python physical computing"

GET INTO PROGRAMMING

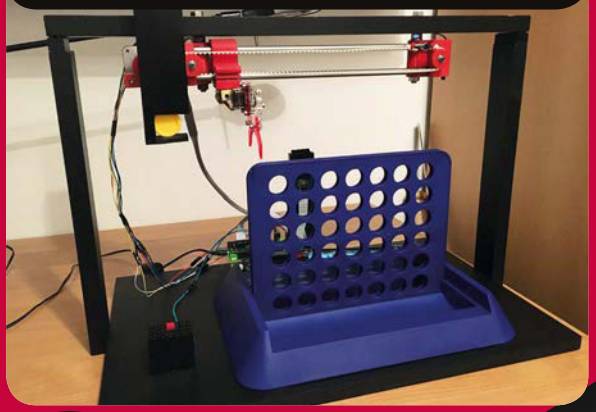
Programming is a learning process that requires steps to understand different concepts. Just one tutorial won't be able to do the job, which is why we have entire books on the subject. Of particular interest for this category is our *GPIO Zero Essentials* book, which teaches you how to use the library on Python. There are also books on hacking Minecraft Pi and creating games in Python and Scratch. You can find them all here: **magpi.cc/Back-issues**

4-BOT

20

CREATED BY: David Pride
URL: magpi.cc/1XrC3zU

FAST FACT:
With capturing and processing the image, calculating the next move, and delivering the counter, the total time per turn is around 25 seconds



Prepare to be amazed by the 4-Bot, created by David Pride. This robot plays Connect Four by taking a picture of the game board, processing the colours, and then giving the program the state of the board to calculate the next move.

David reveals, "There are a huge but finite number of solutions, and they can all be calculated with enough processing power. The trade-off is in the depth of search and therefore the time taken to calculate each move... If you increase the search depth, this massively increases the calculation time. So I selected a middle ground where the bot plays a pretty mean game, but the total time per move is still acceptable."

MAKER SAYS "In terms of how well it plays, Connect 4 is a 'perfect' game in mathematical terms"

19

CREATED BY: Scott Garner
URL: magpi.cc/2d3lhpB

FAST FACT:
No electrical components are visible in the project

BEETBOX

One of the craziest projects is this work of wonder. The BeetBox is a musical instrument that allows drummers to play drum beats by tapping on beetroots.

The project mounts six large beets and an audio amplifier in a wooden enclosure, and a Raspberry Pi armed with a capacitive touch sensor is used to control touch and response.

Scott says, "I'm particularly interested in creating complex technical interactions in which the technology is invisible, both in the sense that the interaction is extremely simple and in the literal sense that no electronic components can be seen."

MAKER SAYS "The BeetBox is primarily an exploration of perspective and expectations"

18

CREATED BY: Jonathan Moscardini and McMaster University students
URL: magpi.cc/2d3mo8x

FAST FACT:
The students don't just build the car; they have to personally race it, too

MCMASTER FORMULA HYBRID

Engineering students from McMaster University enter the Formula Hybrid and EcoCAR 3 competition every year.

Their hybrid race car doesn't lack muscle: it packs a 15kW in-hub motor for the front wheels, and a 250cc motorcycle engine for the rear wheels.

But their secret weapon is the Raspberry Pi inside the car, which acts as a dashboard computer and team radio. It gathers telemetry data and sends it to the team at trackside, enabling them to analyse the car's performance.

MAKER SAYS "Essentially it's both the dashboard computer and our team radio. It also gives us a few new features along the way, simply because it's so powerful"

17

CREATED BY: Martin Mander
URL: magpi.cc/2d3pedC

FAST FACT:
The project took six months to complete (we think it was worth it)

RASPBERRY PI VCR

If you're not old enough to know what a VCR was, ask your parents. You did have to hook it up to a TV, but being able to lug one around was quite a novelty back in the 1980s.

"I picked [this] up for 'spare or repair' on eBay for £6," explains Martin. "I stripped out all of the internal circuits and replaced them with modern tech, with the Raspberry Pi running the show, a powered USB hub housed in a pop-out VHS tape, an Arduino-powered clock, and a 15˝ HD TV panel integrated into the back of the unit."

16

CREATED BY:
Aether & Hemera
URL: magpi.cc/2d3mGfC

FAST FACT:
Each boat is 60cm long, 27cm wide, and 21cm high. The total installation covers over 1,000 square metres

VOYAGE

Voyage is an impressive art installation. There's a Raspberry Pi acting as a DHCP and web server as part of the control mechanism. We find ourselves surprisingly touched at the blending of Raspberry Pi and something so beautiful. Conceived by Newcastle-based studio Aether & Hemera, the art project is made from coloured paper boats on water. People can engage with the lights from their mobile phone. "The aim of the artwork is to allow viewers to travel and sail with absolute freedom to all the places they care to imagine," says the studio's website.

MAKER SAYS "'Voyage' comes from the Latin 'viaticum', which means provision for travelling"

TEAM PICKS

Rob Zwetsloot
Features Editor

PIGRRL
I've always been a big fan of miniaturised Pi projects that allow you to play games, retro or otherwise. We've had mini NESes, Pi Zeros in controllers (one of those thanks to me), and even lots of mini-arcade cabinets. What I love about the PiGRRL and all its different versions is the portability and the fantastic custom case to go with it, as well as not having to take a bag of games with you everywhere.

Russell Barnes
Managing Editor

PORTABLE PI VCR
I had the pleasure of meeting Martin Mander at a Cambridge Raspberry Jam, just when I was developing the Project Showcase section for the magazine. I was looking for beautiful, well-crafted projects and I was immediately smitten by this retro chic design; I started the write-up on the spot.

THE BEST PROJECTS FROM YOUNG MAKERS

The Raspberry Pi was created to get kids interested in coding – here's the best of what they're doing...

JUDGE

Liz Upton

Director of Communications, Raspberry Pi

Liz is one of the founders of the Raspberry Pi Foundation. She's been running the comms department – press, website, publications, social media, and design – since 2011.

From the very start, one of the best things about working at Pi Towers has been meeting some of the extraordinary kids who make things with the Raspberry Pi. We met one of the very first, Liam Fraser, when he was making Raspberry Pi tutorials as a 17-year-old back in 2012: he graduated this year, and now works on the engineering team that designs your Pi. Every year, there's a new batch of imaginative, smart, engaging young people who have discovered the Raspberry Pi for the first time, and every year they amaze us with the scope and professionalism of what they're doing.

1 **CREATED BY:** Emma
URL: magpi.cc/2ctkH4q

VERMONT POSTER

In the UK we don't tend to get these kind of big school projects that are so popular in the USA, and in this case we're quite jealous. At this particular American school, second-graders put together a state board, and Emma went the extra mile making hers. It included lights and sounds and was designed in a way that Emma could make it herself with only minimal adult supervision.

LIZ SAYS "Emma was in the second grade when she made this, and to demonstrate that she'd done it all herself, her dad filmed the whole build process, from soldering iron to final working model"

2 **CREATED BY:** Sonia Uppal
URL: magpi.cc/2cpHOQJ

PI A LA CODE

When trying to create education materials for kids and teens, it's important to hear what they have to say about the materials. Sonia was first exposed to computer science while at middle school in Bangalore and found it boring, yet when she returned home to San Francisco she became interested when other methods were presented to her. When she found out about the Raspberry Pi, she decided to create a way of teaching computing to kids in rural India with her own, more interesting curriculum and it's been a great success.

LIZ SAYS "Sonia Uppal has made more of an impact with her extracurricular project than most of us manage in our whole careers"

3

CREATED BY: Oliver and Amelia
URL: magpi.cc/2ctpvqH

BEE BOX

Oliver and Amelia may be the youngest makers in this feature, at age five and seven respectively at the time they created the Bee Box. The box has reed switches triggered by a magnet in the bee, to detect its position. Scratch was used to program a little game, where the bee is placed on the flower and then the beehive. There are pictures and sounds to go with it as well.

LIZ SAYS "I bump into Oliver and Amelia a couple of times every year at Pi events. They're a brilliant pair, full of enthusiasm and imagination. This project captures all of it"

4

CREATED BY: Benton Park Primary School Code Club
URL: magpi.cc/2cpTqTG

BENTON PARK LIVE CODING ORCHESTRA

If you've ever read the tutorials from Sam Aaron on Sonic Pi in the magazine, you'll know he's always trying to teach people about live coding with it. Some primary school children took this to heart and put on a live-coding orchestra using Raspberry Pi and Sonic Pi, with music and graphics, for a very excited audience. They came back later to perform music based on the planets, with a little bit of Holst inspiration.

LIZ SAYS "A brilliantly expressive use of the Raspberry Pi: music created with Sonic Pi and some kickass dancing. I could watch this all day"

GETTING KIDS INVOLVED

The reason the Raspberry Pi exists in the first place is to get more young people into computer science again after a drop in university applications to the subject. Getting the Raspberry Pi is only the first step; inspiring and teaching children about the Pi is the next one. Attending Raspberry Jams (see our Events section on page 88) or finding your nearest Code Club (**codeclub.org.uk**) is a great way to get for kids to learn about what they can do with a Raspberry Pi and coding.

5

CREATED BY: Zach Igielman
URL: magpi.cc/1OALwNT

PIPIANO / PIANO HAT

The PiPiano was originally a crowdfunded Raspberry Pi add-on that allowed you to make music or even just have a multi-button add-on for the Pi. It did extraordinarily well, worthy enough on its own to be on this list; however, the concept was later turned into a proper product by the folks at Pimoroni. Based on Zach's creation, and made with his permission, the Piano HAT uses touch-sensitive buttons rather than physical ones.

LIZ SAYS "Pimoroni turned Zach Igielman's original into something that would still be one of my favourite add-ons for the Pi even if it hadn't been invented by a 14-year-old"

15

CREATED BY: Graham Gelding
URL: magpi.cc/1qODcFy

FAST FACT:
The most expensive parts of the project are the LCD screen and some of the controls

COFFEE TABLE PI

Graham Gelding has created the ultimate in classy, grown-up arcade gaming apparatus: a cocktail arcade cabinet.

"It was an attempt to recreate the classic arcade cocktail cabinet," Graham tells us, "but in a way that can fit into a lounge. It's also a way of introducing my kids to the games that I had growing up."

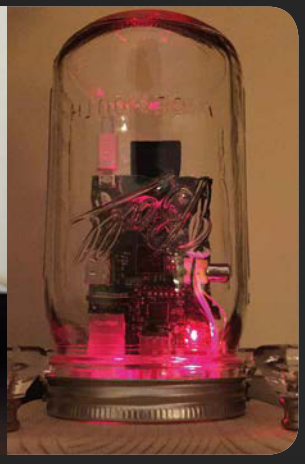
Looking for a project for his Raspberry Pi, Graham also wanted to try some woodworking. He made the whole table from scratch using pine from an old bookshelf, as well as installing the screen, arcade controls, and the Raspberry Pi itself that powers it.

MAKER SAYS "The two projects seemed perfect. I could make use of my experience with Linux, but also learn about woodworking"

13

CREATED BY: Matt Reed
URL: mcreed.com

FAST FACT:
Matt used Node.js to get the LEDs to work in time with BitTorrent



LIFEBOX

You could be forgiven for thinking that the LifeBox was just another neat little programmed series of LEDs. This would be a huge mistake to make, because the little lights are a lot cleverer than you could imagine: they're alive. Well, sort of. At the very least, they have been programmed with behaviour.

"In this box live two pixelic entities, the blue and yellow species," says Ferran. "These two species compete to survive and reproduce, feeding [on] the white mana that grows under [their] feet."

MAKER SAYS "Since I was a child, I was attracted to robotics and the possibilities of simple life simulations"

14

CREATED BY: Ferran Fàbregas
URL: magpi.cc/2cKR1Ds

FAST FACT:
The project took two months to complete

MASON JAR PRESERVE

The Raspberry Pi-powered Mason Jar Preserve is the most stylish backup solution we've ever seen.

"[Mason Jars] are industrial-grade glass jars with a sealable lid that were originally used at home to preserve foods throughout the winter," says Matt. "Mason Jars allowed for foods that were harvested in the summer to last all year round. Who doesn't want tasty fried okra in February?" Matt used BitTorrent to create the backup software. "It's similar to Dropbox," he says, "but instead of a centralised server in the cloud, you connect two or more of your own devices directly together over the BitTorrent protocol."

MAKER SAYS "I used a saw to cut the base into a square, a sander to round it off, and a drill to make the LED, Ethernet, and power holes"

12

CREATED BY: Hitchin Hackspace
URL: magpi.cc/2cKRLIr

FAST FACT:
Bighak is driven by two electric wheelchair motors and has a chassis made from recycled space-age aluminium honeycomb

BIGHAK

Makers and coders of a certain age go all misty-eyed at the mere mention of Bigtrak. This toy, created in 1979, had kids across country issuing commands to a robot, such as go forward for one second, and turn right 90 degrees.

"Well, Bighak is very similar," say its makers, "but on a rather larger scale – 5.2:1, to be precise."

Bighak allows the 'commander' to ride around in the rear, while issuing commands by holding up QR codes to the webcam. A Raspberry Pi turns the commands into directions and Bighak trundles off.

MAKER SAYS "The combination of nostalgia and the outrageousness of the suggestion was enough to provoke further conversation ending in the fateful words 'You know what, I think we could do it!' "

11

CREATED BY:
Johan Ten Broeke & Jeroen van Goor
URL: magpi.cc/2cKSeug

FAST FACT:
The mirror is displayed at Fullscreen.nl's Netherlands office

LED MIRROR

Created as an art installation, the LED Mirror consists of a staggering 2,048 LEDs. When someone stands in front of it, a camera picks up their movement and creates a series of snazzy effects.

The project began on a small scale. "We built a prototype of several small 8×8 LED dot matrix digits," Johan explains. It soon grew.

The effect is nothing less than stunning. "Although the displayed images are very abstract, spectators identify themselves instantaneously due to the feedback of their motions. This triggers people to move and wave in front of the mirror," says Johan.

FACEBOOK FAVES

These projects reached the most people on FaceBook (via shares and likes). You can follow *The MagPi* on Facebook at **facebook.com/MagPiMagazine**

360 Camera

REACH: 33,030 PEOPLE

Create 360 video awesomeness on your Raspberry Pi. This project records omnidirectional video and posts it directly to YouTube.
magpi.cc/2cd00fa

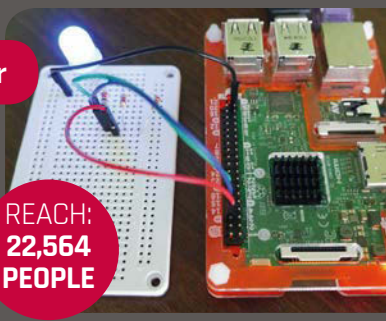
Retro SNES sculpture

REACH: 31,023 PEOPLE

Hand-carved from clay, this micro-console was a firm favourite with *The MagPi* social community.
magpi.cc/2bSJKKZ

RGB Tweet-o-meter

REACH: 22,564 PEOPLE



Control an RGB LED and see how well your tweets are doing.
magpi.cc/2bXJoHf

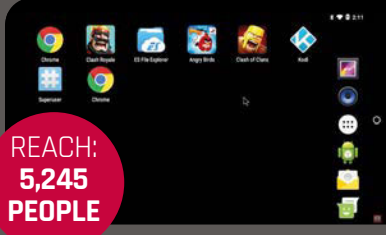
Pi-Powered Sub

REACH: 10,735 PEOPLE

Rather than taking to the skies like most Pi-powered drones, this ingenious ROV dives beneath the surface for some underwater exploration.
magpi.cc/20TfFiE

RTAndroid

REACH: 5,245 PEOPLE



Install Android with RTAndroid on a Raspberry Pi 3.
magpi.cc/2bNHh4w

THE BEST PROJECTS FOR GOOD

Let's celebrate the Raspberry Pi projects that help people and communities, from health to education

JUDGE

Philip Colligan

CEO,
Raspberry Pi Foundation

Philip Colligan is chief executive of the Raspberry Pi Foundation. He is also a craft cider maker, school governor, and dad to two young digital makers.

All over the world, people are harnessing the power of digital technologies to solve problems that matter to them. One of the most powerful things about Raspberry Pi computers is how they have dramatically lowered cost barriers, meaning that many more people are able to take advantage of the latest technologies to create exciting new innovations. Just as important is the awesome global community of entrepreneurs, makers, and educators that provides inspiration, shares learning, and gives practical support. This combination is massively accelerating the pace at which new solutions are being created to solve big social problems. It was hard to pick just five, but here are a few of my favourites from the many examples we've found.

1 FARMBOT

CREATED BY: FarmBot, Inc
URL: farmbot.io

Growing your own vegetables is one of those ideas that sounds great in theory, but in practice can be a lot of work. It's not for everyone, but if you just want to eat the result of the labour and you have some money to spend, then the FarmBot could be for you. It's an incredible product that can also be scaled up to help feed communities.

PHILIP SAYS "A beautifully designed and automated food production system. Powered by a Raspberry Pi computer, this completely open-source project aims to change the way we produce our food"

2 RACHEL PI

CREATED BY: World Possible
URL: worldpossible.org

RACHEL is educational server software that contains everything you'd need students to access, with the idea being that servers can be set up in places where there is no internet and act as an 'offline internet', albeit with only the relevant content you need. The RACHEL Pi is a Raspberry Pi loaded with the software which costs only $99, but which can open up a wealth of possibilities to people around the world.

PHILIP SAYS "Bringing knowledge and education to parts of the world that the internet hasn't yet reached, using Raspberry Pi and the power of social entrepreneurship. What's not to love about this?"

EDUCATION WITH THE RASPBERRY PI

It's no secret that the Raspberry Pi Foundation's main mission is to spread and facilitate computing education. The Raspberry Pi computer itself aids in this by lowering the cost of actually purchasing a computer. Projects on this page like RACHEL and Pi4L are wonderful uses of the Raspberry Pi for just that, but you don't need to go that far to use the Pi for educational purposes. The Raspberry Pi Foundation has produced a ton of teaching materials that are all freely available for everyone to use and can be found via: **magpi.cc/2ctbKrV**

4

CREATED BY: International Education Association
URL: iea.org.lb

PI4L THE PI FOR LEARNING

The Pi4L Labs, about 12 to 25 Raspberry Pis that students work on, helped teach refugee children basic numeracy skills, visual programming (via Scratch), and social and health awareness. It could also guide the teachers themselves so they could better educate the kids using the resources provided by Pi4L. Lessons aren't just provided while on the computers either, with 'unplugged' lessons included as well.

PHILIP SAYS "Using Raspberry Pi computers as part of a Unicef-backed educational programme to support Syrian refugees living in Lebanon, this has already delivered impressive results"

3

CREATED BY: Dana Lewis and Scott Leibrand
URL: diyps.org

DO-IT-YOURSELF PANCREAS SYSTEM

Also known as the #DIYPS, it was developed to solve a known issue with an existing medical device on the market that had been FDA approved, and it did. In the process, its makers were also able to add features such as real-time processing of blood glucose, real-time predictive alerts, and continually updated recommendations on required insulin and carbs. The code has been released as OpenAPS so other people can build their own custom system: it's literally DIY.

PHILIP SAYS "A system built around Raspberry Pi for continuously monitoring blood glucose levels for people suffering from diabetes, helping them to manage diet and medication, and ultimately to live longer, healthier lives"

5

CREATED BY: Media in Cooperation and Transition
URL: magpi.cc/2cnCJID

POCKET FM

Protecting true free speech in small parts of Syria, the Pocket FM helps people gain access to audio content from Syrnet. It's a radio channel maintained by humanitarians and Syrian ex-pat journalists to broadcast news, language programmes, and even music to people who don't want to rely on government-controlled news feeds – whatever government that might be. It can be powered by a car battery or solar power and is small and easy to hide.

PHILIP SAYS "Bringing independent radio to cities in Syria through low-cost, portable radio devices built on Raspberry Pi computers that convert satellite signals to FM so that everyone can access them"

RASPBERRY PI NOTEBOOK

This beautiful retro-styled mini-notebook, built by Adafruit's Ruiz Brothers, is powered by a Raspberry Pi and an Adafruit 3.5″ PiTFT touchscreen and, frankly, not a great deal more!

Besides the Raspberry Pi 2 and PiTFT display, for control the project features a mini-chiclet keyboard with built-in trackpad. It's a widely available wireless input device that's both affordable and easy-to-use.

While the hardware is the really exciting bit, the 3D-printed chassis is a work of art, too.

Take, for example, its totally modular hinged design. While it works really well on this Raspberry Pi mini-notebook, you could reuse it for 101 different hardware projects.

10

CREATED BY: The Ruiz Brothers
URL: magpi.cc/2dboNwS

FAST FACT:
You can find a full shopping list of parts, software, and 3D printing files on the Adafuit Learning system

9

CREATED BY: The Ruiz Brothers
URL: magpi.cc/2dbpFBJ

FAST FACT:
You can attach Pi Glass to prescription glasses (unlike Google Glass)

PI GLASS

The good people at Adafruit posted a tutorial on making a wearable display, powered by a Raspberry Pi, that clips on to your regular glasses or (if you're a Terminator with perfect vision) sunglasses.

"Our 3D-printed design turns a pair of 'private display glasses' into a 'Google Glass'-like form factor," say the Ruiz Brothers. "It easily clips to your prescription glasses, and can display any kind of device with composite video, like a Raspberry Pi."

MAKER SAYS "Hack together your own Google Glass wearable using a Raspberry Pi"

8

CREATED BY: Raspberry Pi
URL: astro-pi.org

FAST FACT:
Seven experiments, designed by schoolchildren, were performed aboard the ISS

ASTRO PI

During 2016, the United Kingdom looked to the skies as British ESA Astronaut Tim Peake served aboard the International Space Station.

Two special Raspberry Pis joined Tim up in space. The Astro Pi devices, nicknamed Ed and Izzy, had their own mission to carry out experiments – some aided by Tim himself – coded by UK schoolchildren.

Raspberry Pi's space adventures aren't over. "We hope to see Raspberry Pi-derived hardware in CubeSats in low Earth orbit and maybe beyond," says Eben Upton, CEO of Raspberry Pi. "We've been wondering if SpaceX have any room on their Red Dragon mission in 2018."

TIM PEAKE SAYS "I've been amazed by how many kids and adults have been encouraged and inspired to take up programming"

7

CREATED BY: Fl@c@ (pronounced 'flatcat')
URL: magpi.cc/2dbpuWQ

FAST FACT:
The project made it to the final of the 2014 Hackaday Prize comptition

RAMANPI

Raman spectroscopy is a molecular identification technique that works by detecting and analysing the characteristic ways in which substances absorb and emit radiation. Raman spectrometers can identify chemical compounds from tiny samples, and are non-destructive.

They're also very expensive pieces of kit. This ramanPi spectrometer uses a Raspberry Pi and 3D-printed parts, together with readily available off-the-shelf components. It's an astonishing contribution to the open source movement that's likely to be of interest to schools, chemists, biologists, home brew enthusiasts, people who want to know what's in their water, businesses, ecologists, and the simply curious.

MAKER SAYS "Ordinarily, an expensive notch filter would be used which is cost prohibitive for most average people"

6

CREATED BY: The Ruiz Brothers
URL: magpi.cc/2dbpjLx

FAST FACT:
The display is a touchscreen, so you can also play modern swipe-based games

PIGRRL

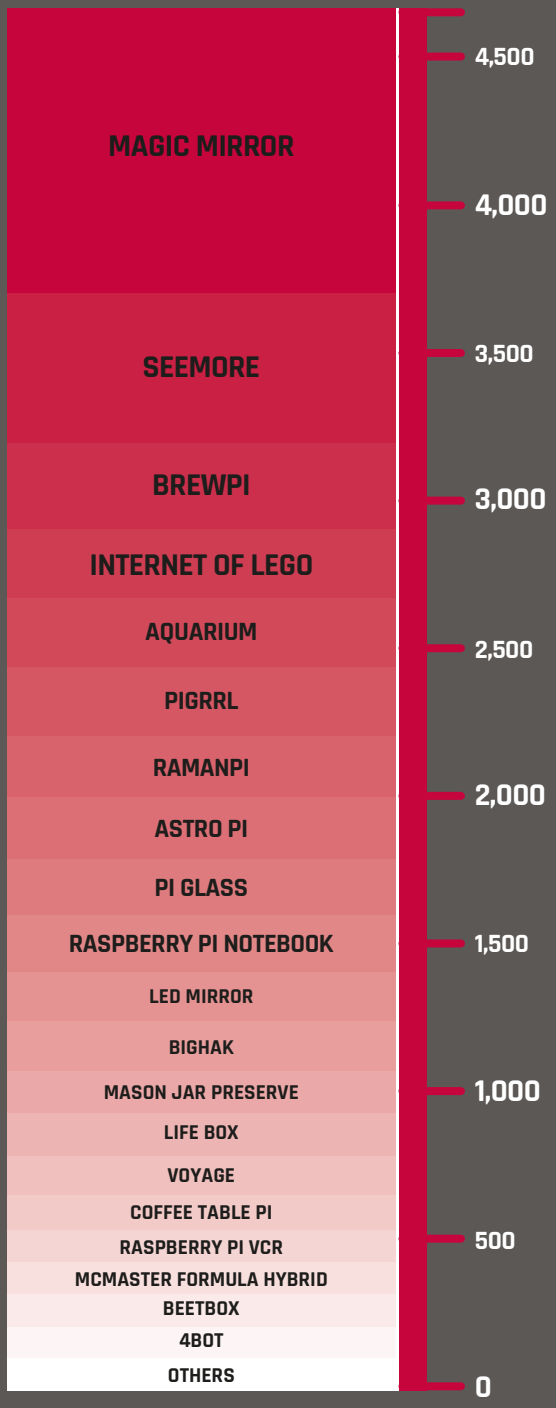
To celebrate the 25th anniversary of the Nintendo Game Boy console, Adafruit came up with this great emulation project.

It's been through a few iterations, and the latest Pocket PiGRRL uses a Raspberry Pi and PiTFT HAT (320×240 pixels) to create a portable gaming console.

While you're free to set up the software side of the project in any way you like, the Ruiz Brothers have opted to use RetroPie (**magpi.cc/2cqNyJW**), a great emulation package for the Raspberry Pi that enables users to play games from all sorts of classic systems.

VOTE COUNTING

We gathered votes from 4,625 readers who told us their favourite projects. The most popular project was Magic Mirror, with 17.9 percent of the vote. SeeMore came in second, with 9.5 percent. BrewPi, Internet of LEGO, and Aquarium all gained around 5 percent of the vote each. The rest of the voting was split between the Top 20 projects listed here, and other (still very cool) projects.



5

CREATED BY: Michael Gronau
URL: magpi.cc/2cxpup1

FAST FACT:
The aquarium can set five different degrees of cloudiness

AQUARIUM

Create the ultimate environment for your fish using an IoT tank

A seriously cool home for all your fishies, this special aquarium in Germany allows the fish to experience what it would be like to be swimming around a reef off the Cayman Islands. Honestly, we're pretty jealous of the fish. Maybe they all have offshore holdings there?

A paradise for fish. We wonder how a tropical storm affects the tank...

The main way it simulates the Caymans is by changing the water temperature, and illuminating the tank in a specific fashion using a series of LEDs above the tank. The light takes into account not only the amount of sunlight but also dawn and sunset, along with the moonlight! The Raspberry Pi is the key to figuring this part out, as it polls a Cayman Islands weather station every couple of minutes and then makes the necessary changes.

All the lights are controlled by an Arduino and there's even a web interface in case you think the fish are having too good a time and want to bring them back to the reality of where they actually are. Apparently, it's been working well long-term and we sincerely hope the fish are enjoying their extended Holodeck-esque staycation.

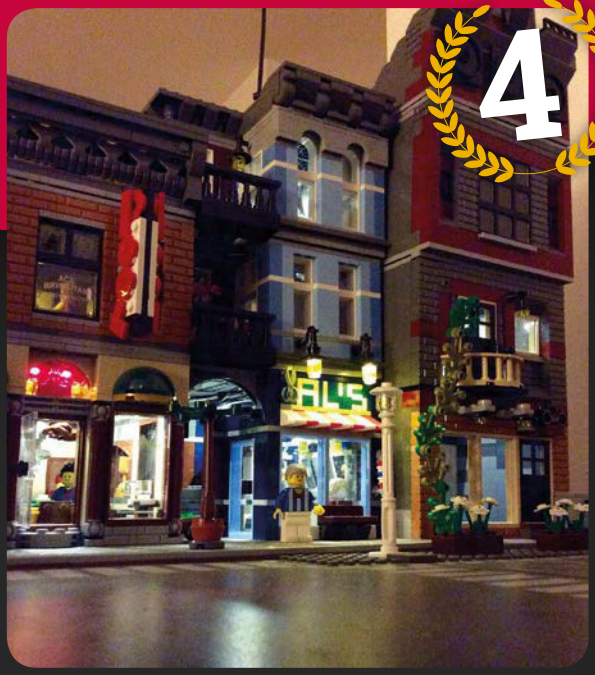
MAKER SAYS "What I like with this build is the possibilities you have with LEDs"

CREATED BY: Cory Guynn
URL: internetoflego.com

FAST FACT:
Cory has been working on Internet of LEGO since September 2015

INTERNET OF LEGO

An electronic LEGO city that's online and teaching its maker about IoT



We've seen many Raspberry Pi projects where people have created an incredible thing just to learn about it. The Internet of LEGO's creator Cory has previously described it as a 'living project'; from his blog you can see how it has been built up over time, not just in terms of LEGO bricks, but also by adding internet-controlled bits and pieces.

He first started with some simple lights, but since then he's added mechanisms that drive lifts and rail crossings that also use motion sensors and the like. A lot of it is programmed with Node-RED, the building-block programming language.

There's a working train track around the city that's one of Cory's favourite parts. "I love seeing things in motion," he tells us. "There are several things that I've been able to do that make for a dynamic environment." It links up to the Transport for London API, which helps schedule the train and also gives live changes to its destination. You can even read where it's going on a little OLED screen.

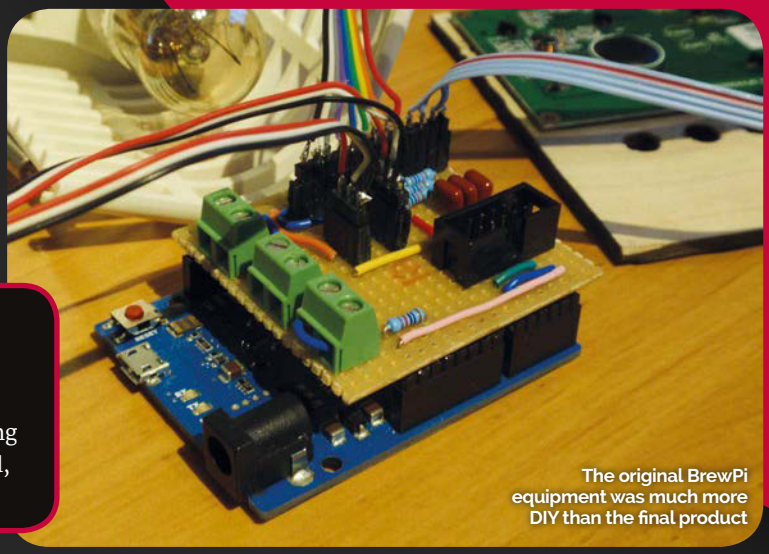
Cory's amazing feats are in part due to the help from the open-source community: an integral part of Pi projects, it seems.

MAKER SAYS "My goal with this project is to learn tech, and inspire our future engineers and those who want to better understand these exciting new technologies"

3

CREATED BY: Elco Jacobs
URL: brewpi.com

FAST FACT:
The BrewPi team are working on supporting mash control, another aspect of brewing



The original BrewPi equipment was much more DIY than the final product

BREWPI

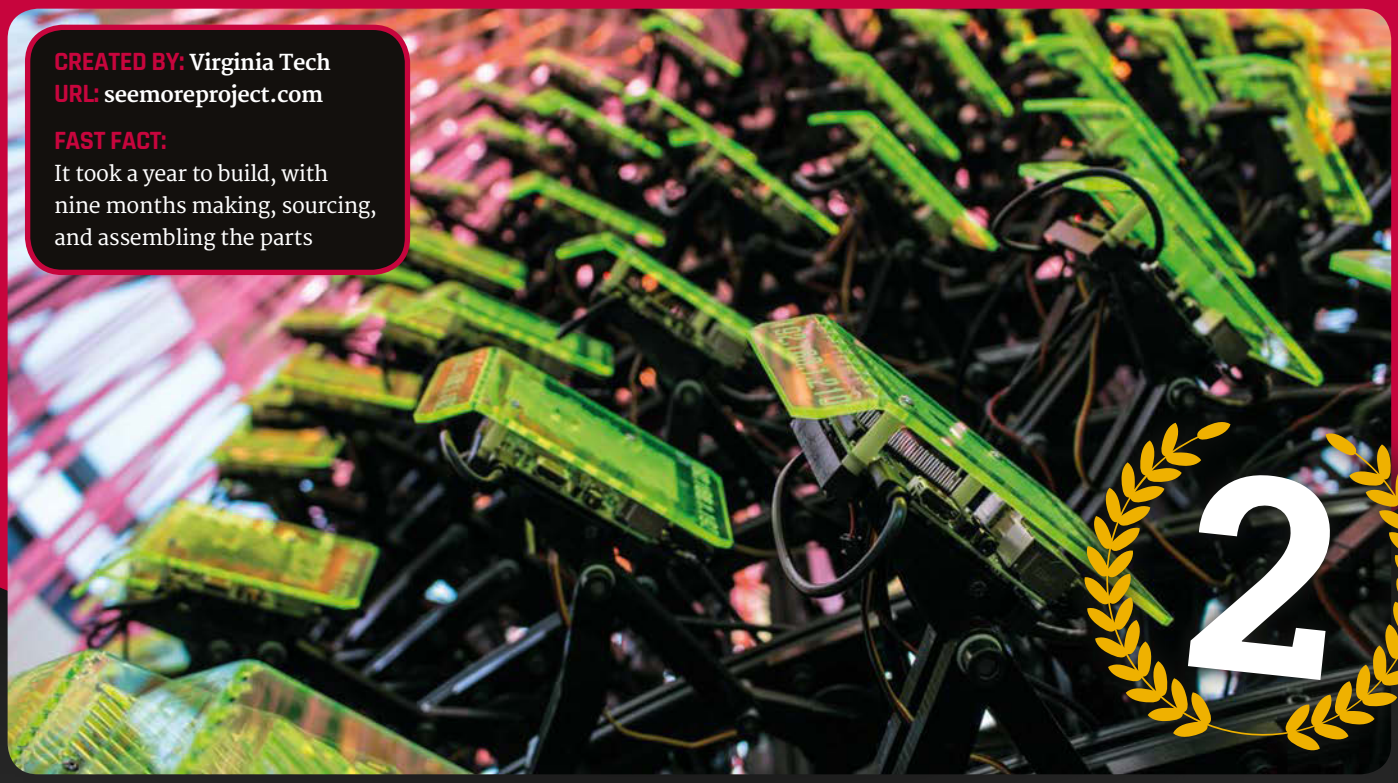
Brew the perfect beer using your Raspberry Pi to control the process

This is one of the earlier, pioneering Raspberry Pi projects, having been initially completed in 2012 when the Raspberry Pi and the community were still in their relative infancy. One of the important things about brewing beer (and wine) is controlling the temperature of your batch, which is where the BrewPi comes in.

It's since been made into a product that the maker Elco Jacobs develops and sells, claiming it's more accurate than other similar products while also allowing you track data through a web interface – an Internet of Beer, if you will.

There's other features as well, such as programmable temperature profiles and the like, but all in all it's a great example of how a community project turned into a fully fledged product. Although you may need to hack an old fridge if you want to brew some truly special beer, luckily there are guides on how to do that (using your BrewPi) on the website.

MAKER SAYS "Compared to other temperature controllers, BrewPi offers much better temperature control"



CREATED BY: Virginia Tech
URL: seemoreproject.com

FAST FACT:
It took a year to build, with nine months making, sourcing, and assembling the parts

2

SEEMORE

A Raspberry Pi sculpture that's also secretly a supercomputer

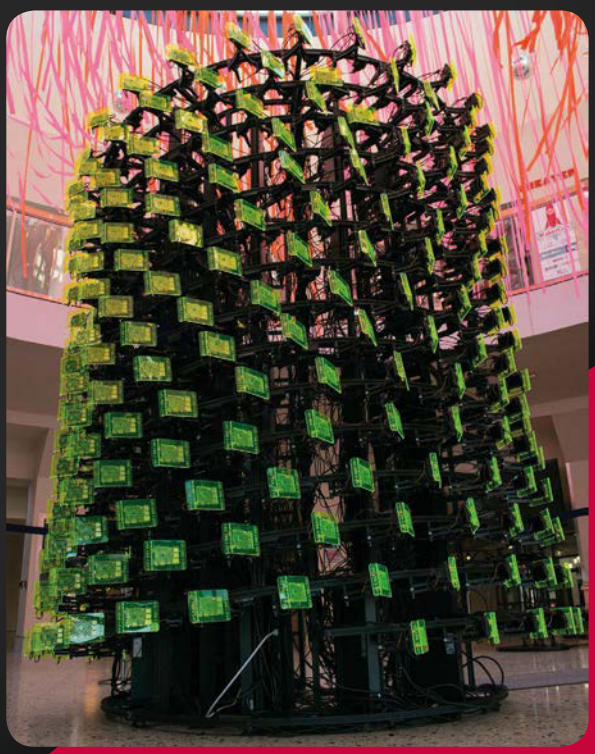
As far as we can tell, this sculpture also holds the record for the number of Raspberry Pis working together in parallel. With 256 linked together in this massive work of art and tech fusion, it can probably crunch some serious numbers if you wanted it to.

It was exhibited at the World Maker Faire New York at the end of 2015, and used 834 metres of wiring to get it all hooked up and working. A lot of the parts were custom-made via CNC and laser etching, but the coolest thing about the piece was how the panels covering each Pi would move depending on how much computational power was being used.

"The movement of the Raspberry Pis is actually a curve... so it doesn't just flap out, it articulates outward," one of its creators Sam Blanchard reveals. "It has a double linkage that some might see as superfluous or overly complex, but I think that what you get... is this waveform that relates to these ideas of fluidity, and that springs from what a lot of parallel computers are built to process: things like weather simulation or fluid dynamics."

It's not on permanent display (there's no room at Virginia Tech for it), but it does make appearances at exhibits around the world, so keep your eye out for it.

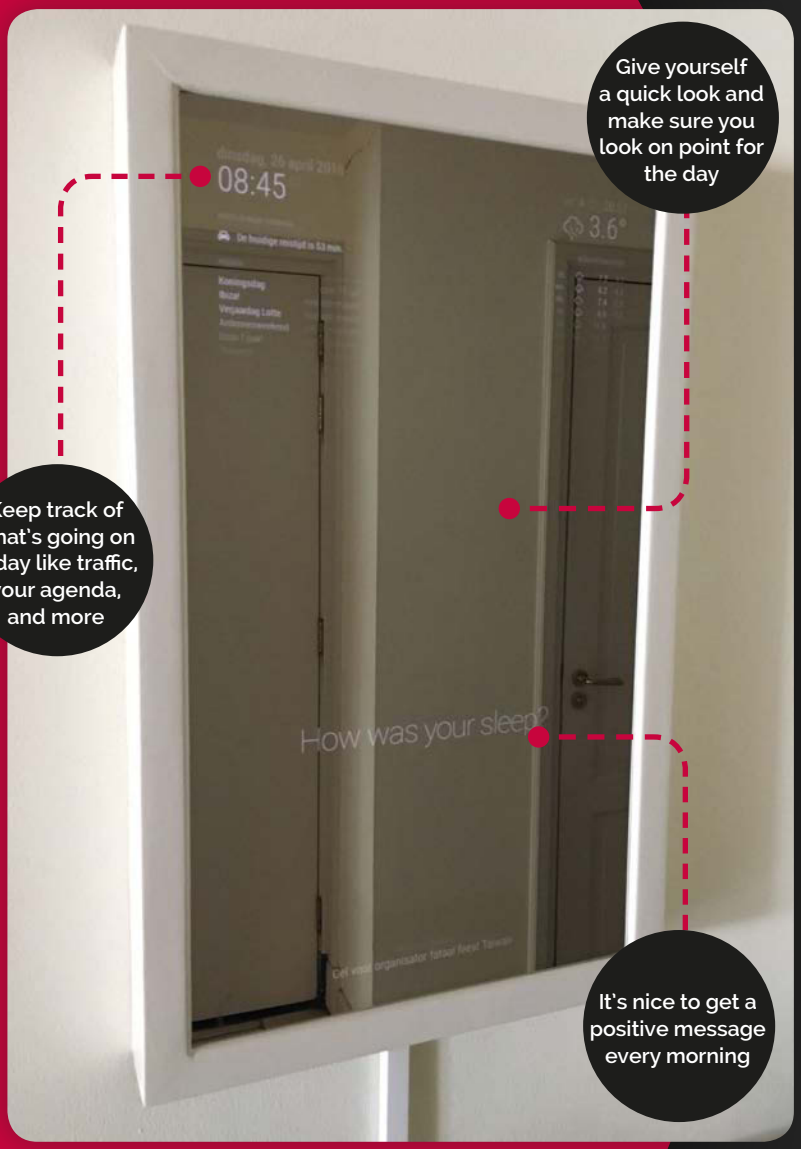
MAKER SAYS "SeeMore was designed to combine computer science and art to engage, educate, and inspire broad audiences on the importance and beauty of parallel computational thinking"



1 MAGIC MIRROR

CREATED BY: Michael Teeuw
URL: magicmirror.builders

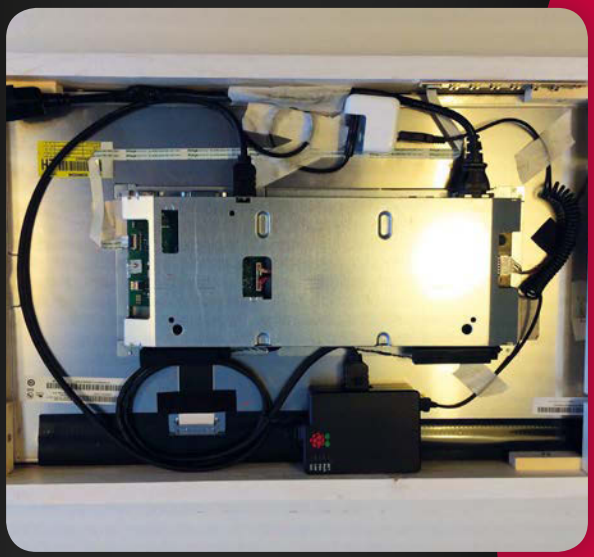
FAST FACT:
The original prototype took a couple of weeks to build


Give yourself a quick look and make sure you look on point for the day
08:45
3.6°
How was your sleep?
Keep track of what's going on today like traffic, your agenda, and more
It's nice to get a positive message every morning

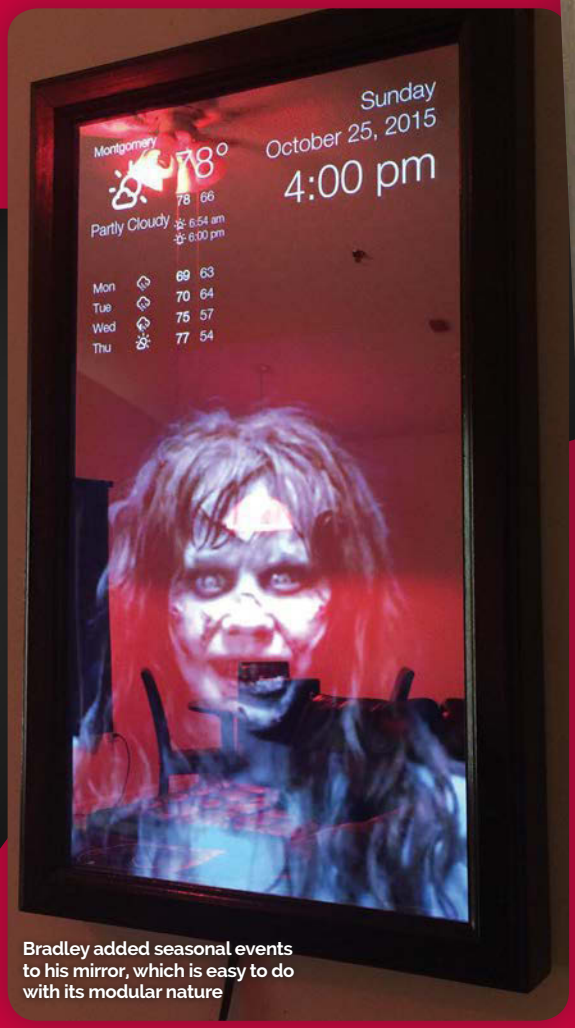
A mirror into your life, or at least the parts that are available online

If you've ever been on the Raspberry Pi subreddit, you'll probably have seen some amazing magic mirror projects posted there. They're always very popular, and for good reason: they're really cool. Here's the kicker as well: with all the hard software work done and available, they're not too hard to make, as long as you're handy with a saw and varnish for some light woodworking.

The project that brought the concept to many people's attention last year was Bradley Melton's mirror, which we featured in issue 40 of the magazine. It looked and worked great, with all the basics you'd need from a 'smart mirror': weather, time, and a nice compliment to get you started in your day. Bradley built the software of his version using preexisting software as a guide so he could understand it, which then allowed him to add seasonal Easter eggs to it like spooky pictures during Halloween.



The hardware inside the mirror is quite simple (and relatively cheap)



Bradley added seasonal events to his mirror, which is easy to do with its modular nature

Bradley's project was featured in issue 40 and was made from scratch, with the original as a guide

The aforementioned preexisting magic mirror software was created by Michael Teeuw, a maker from the Netherlands:

"I was visiting New York with my girlfriend." Michael tells us. "While wandering around Macy's, I noticed a mirror with an illuminated song on it. This is something I could build myself [I thought], only better. I wanted my own magic mirror!"

Michael built the first mirror before expanding upon it with a software project he's dubbed MagicMirror². It's an open-source modular platform so other people can build their own magic mirrors. Since then, magic mirrors like Michael's and Bradley's have popped up on Reddit quite often.

"It's an extremely humbling experience," Michael says of the love for the project. "It feels like a huge compliment that I inspired so many people to build their own mirror and explore the world of the Raspberry Pi."

He's recently started a new website, **magicmirror.builders**, to guide people who want to make their own magic mirror project. It has links to the software and blogs from the build, so you can plan and create your own. However, as Bradley explains to us, it's very easy:

"As long as you have a little bit of carpentry and general DIY skills to build the frame, and have a basic understanding of how to program, you should be able to build this. I have never used JavaScript or CSS before this project, and I only had a little bit of experience with HTML."

Looks like it's time to get building the winner of our top 50 Raspberry Pi projects.

MAKER SAYS "When I started working on my prototype, I could have never guessed the amount of attention the project would get. I am humbled that I was able to inspire so many people."

pi-top

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CREATE

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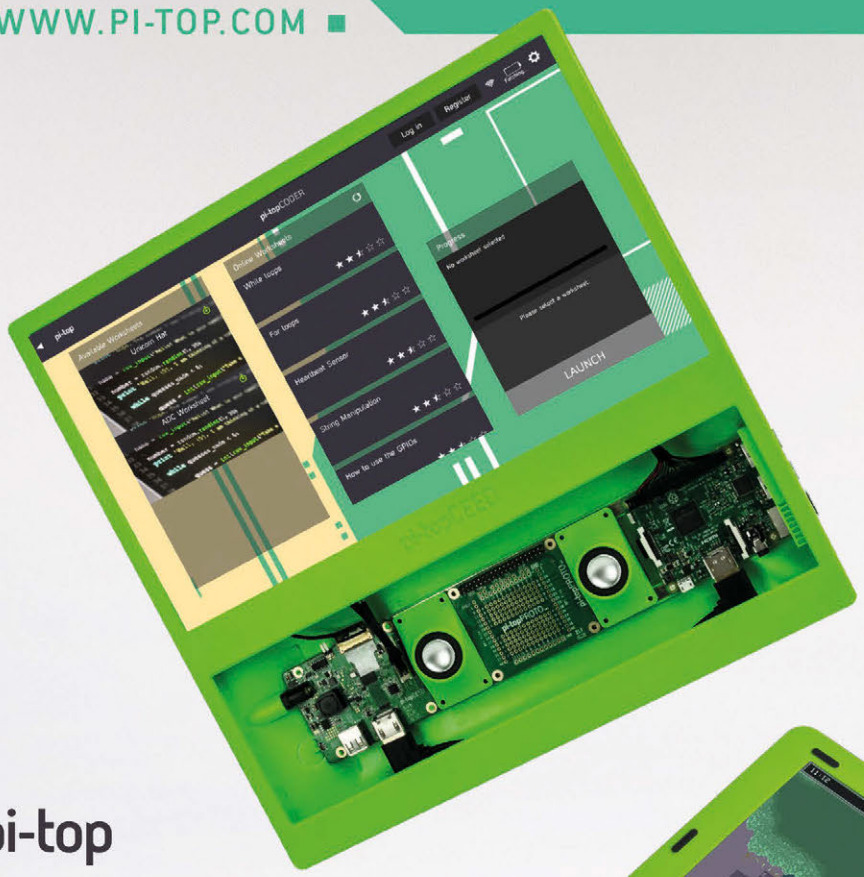

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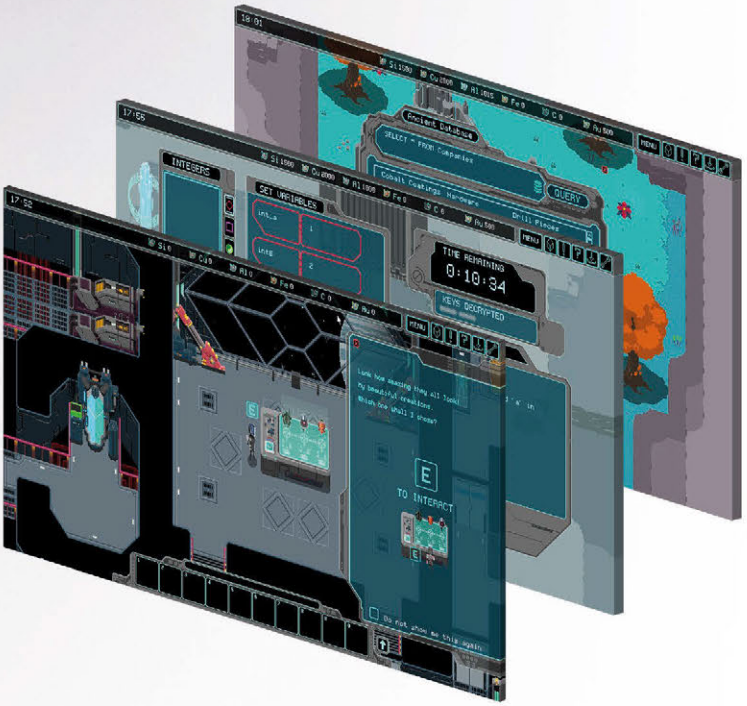

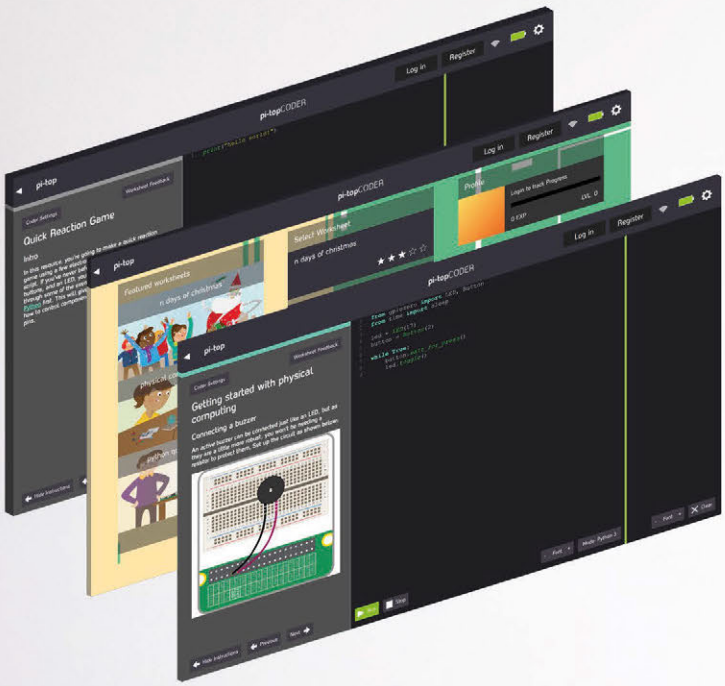

pi-topCODER

Influenced by the workflow of makers and hackers, pi-top presents **pi-top**CODER - an integrated code editor which allows you to learn, write and test code all in one view. With intuitive syntax highlighting, dynamic views and customizable themes it makes for a versatile learning tool for your projects.

pi-topCODER also has every Raspberry Pi Foundation lesson plan created and will track and save your progress as you go through dozens of fun hardware and software projects.

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DAVE PROCHNOW

A writer whose numerous projects, contraptions, and inventions have appeared in *Popular Science*, *Nuts & Volts*, and *SERVO Magazine*.
magpi.cc/2cc7uvj

GO, PIONEER

DIY PORTABLE ACTION CAM

Build your own battery-powered, slow-motion, 90fps action camera to prove you've 'been there and done that'!

You'll Need

- Raspberry Pi Camera Module
- 7× 5mm (T-1 3/4) LEDs
- 7× 430Ω resistors
- Big SPST switch **magpi.cc/2bY3Pmn**
- 3.7V 1000mAh LiPo battery **magpi.cc/2bY3Kiq**
- 5V step-up **magpi.cc/2bMIwmv**
- JST connector **magpi.cc/2bLzvc0**
- 4× 2-inch #6-32 screws
- 4× ⅜- or ½-inch rubber grommets
- Jumper wires

Most adventurers who are thinking about recording an action event would choose to explore the GoPro camera system. While being a very capable recording device that's housed inside a diminutive package, the GoPro cameras have an exorbitant price tag that stops weekend warriors in their tracks. What if an action camera cost less than $50? What if you could build this camera yourself? What if this camera had a fully functional Linux computer inside? Although it might sound like pie-in-the-sky dreaming, these are the hallmarks for our piOneer slo-mo action camera project.

>STEP-01

Print it

Borrowing a page from the Astro Pi design book, piOneer consists of a three-part 3D-printed case that holds a Raspberry Pi, Camera Module, user interface, LiPo battery, and large capacity micro SD card. The case consists of three separate STL files that can be printed on any 3D printer with a 150×150mm build surface. The case's top piece should be printed with a removable support structure. You can download the STL files from here: **magpi.cc/2c3XdUE**.

Flick this switch for both powering the system and capturing 90fps video
This row of LEDs is the user interface for displaying the camera's status
A custom-designed, 3D-printed, high-impact plastic enclosure
Pwr
Ready
piOneer
Slo-Mo Cam
90fps

>STEP-02

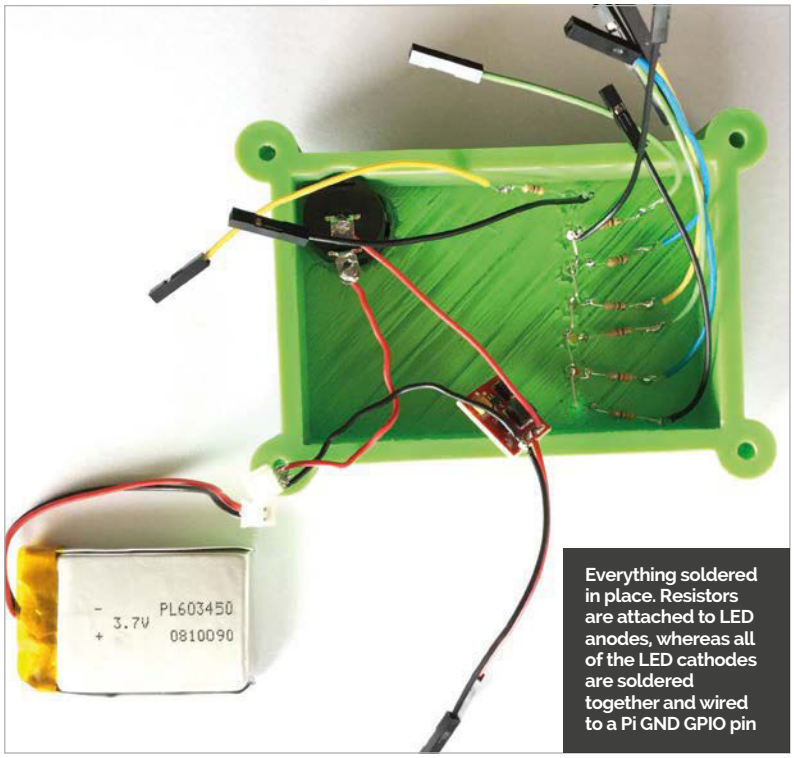
Build your UI

The user interface (UI) for piOneer is dead simple. Consisting of seven LEDs and one switch, the entire UI is housed in the case top piece. Begin your UI construction by gluing the LEDs and the switch to the upper surface of the case top. While you can use the same colour LEDs for piOneer, we opted to mix it up a little: a red LED for power (PWR), blue for ready, white for countdown 3 and 2, a yellow LED for countdown 1, red for recording (Rec), and a green LED for finished. Just one caveat about gluing the LEDs: ensure that all of the cathodes are lined up with each other; this makes the next step very easy to complete.

>STEP-03

Solder your UI

We're going to use a little bit of wiring trickery here! Rather than routing each LED cathode to a separate Pi GPIO GND pin, we're going to connect each cathode together in a daisy chain fashion, thereby using only one GND pin for six LEDs! Begin this wizardry by gently bending the 'finished' LED cathode so that it's touching the 'recording' LED cathode. Now solder these two cathodes together. Continue up the daisy chain, carefully bending the 'recording' cathode until it's touching the 'countdown 1' cathode, and soldering that



Everything soldered in place. Resistors are attached to LED anodes, whereas all of the LED cathodes are soldered together and wired to a Pi GND GPIO pin

connection. Likewise, for the remaining LEDs, bend and solder each LED cathode to the next until you reach the 'Ready' LED. Stop at this LED. Do *not* solder the power (PWR) cathode to this chain: it must be connected to its own GND pin.

Mount the camera module to the 3D-printed base with M2 fasteners

>STEP-04

Wiring your UI

The resistors are each individually soldered to the anodes of *all* LEDs. Begin this process by carefully wrapping one end of a resistor lead around an LED anode lead. The resistor should be parallel to the inside of the top case. Solder this connection, and trim and discard the leftover resistor lead. Add the six remaining resistors to the final LEDs. Solder a jumper wire to the free end of the resistor's other lead. Complete the LED's cathode wiring by soldering a female jumper wire to the power (PWR) LED cathode lead, and one final female jumper wire should be soldered to the daisy-chained cathodes that we created in step 03. The piOneer UI is now complete.

>STEP-05

Adding battery power

The power system for piOneer consists of three sub-assemblies: the power (PWR) LED, the SPST switch, and the battery. While the LED and switch are pretty straightforward fixtures in a do-it-yourself (DIY) project, the battery has one additional component that enables the Pi to run without being tethered to a power outlet. A 5V step-up converter takes the output from the 3.7V LiPo battery and increases it to 5 volts.

The completed project, ready to capture your life's next great adventure

>STEP-06

Wiring your battery

Two wires are individually soldered to the switch's terminals. One of the switch's wires is soldered to the positive terminal of the JST connector. The JST connector is keyed for proper power signal orientation. Use the battery for identifying which terminal is which – remember, the battery's red wire is positive, while the black wire is GND. The other wire from the switch is connected to the IN pad on the 5V step-up converter. A female jumper wire is connected to the OUT pad of the converter. The final pad on the converter is a 'common' GND connection. In other words, both the battery's GND and the Pi's GND must be connected together via this pad. Therefore, solder a wire from the GND terminal of the JST connector to the 5V step-up converter GND pad *and* solder a female jumper wire to this pad. All of the soldering is now finished for piOneer.

>STEP-07

Begin final assembly

The Raspberry Pi and Camera Module will be fastened to the base portion of the case. Note the orientation of the two openings in the base. These openings will hold the Camera Module's lens and status LED. Line the module up with these openings and use four M2 screws for attaching the Camera Module to the base. Lay a rubber grommet on each of the four tall mounting posts, set the Pi on top of the grommets, route the Camera Module's ribbon cable out and over the GPIO pins, and use four more M2 screws for securing the Pi to the base. These rubber grommets will provide a small amount of cushion for the Pi during your upcoming rough-and-tumble adventures. Insert the Camera Module's ribbon cable into the Camera interface connector on the Pi.

>STEP-08

Connecting to the GPIO

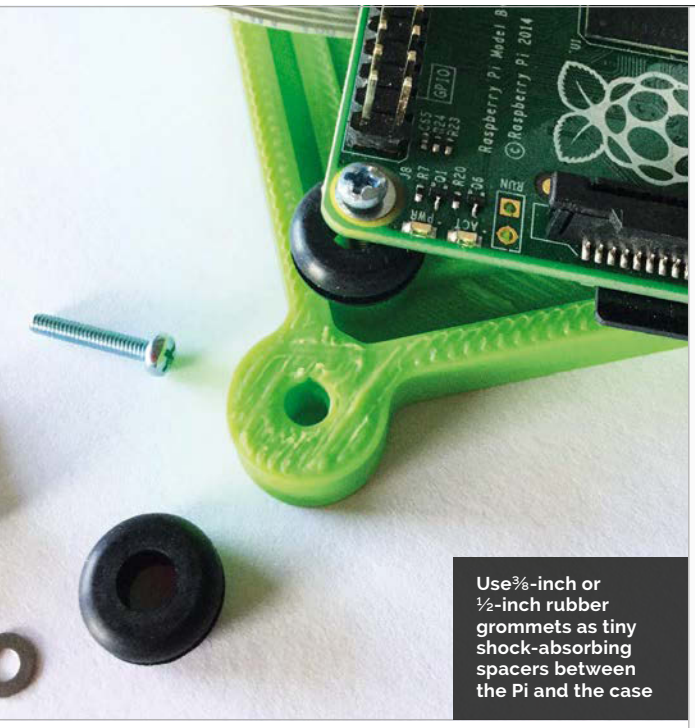
Place the wired-up top case next to the base that holds the Pi. Slip the mid case onto the top case. Connect each of the female jumper wires from the top case to the Pi GPIO pins by following this listing:

GPIO	JUMPER
Pin	Wire
1	PWR LED anode
4	5V step-up converter OUT
6	5V step-up converter GND
9	PWR LED cathode
22	Ready LED anode
16	Countdown 3 LED anode
15	Countdown 2 LED anode
32	Countdown 1 LED anode
33	Rec LED anode
37	Finis LED anode
39	Daisy-chain LED cathodes (see step 03)

>STEP-09

Program the Pi

Carefully and thoroughly examine each and every solder joint and wiring connection, looking for touching wires, solder blobs, connection mistakes, and so on. Fix any problems before connecting your Pi to a power source! When your piOneer passes muster, connect the Pi to a monitor, keyboard, mouse, and USB power source; now set up your Pi so that it boots, with automatic login, to a command-line interface (CLI). These settings will enable piOneer to run automatically without user input every time you



Use⅜-inch or ½-inch rubber grommets as tiny shock-absorbing spacers between the Pi and the case

flick the power switch. Download or enter the piOneer code and save your code to the home directory on the Pi. You can alter the code to suit your recording tastes. As it stands, piOneer will record 1 minute of 640×480-pixel video at 90 fps. The final H264 file will be approximately 65MB in size. In order to make the Python code run automatically, open your user profile for editing:

```
sudo nano /etc/profile
```

...and add this line to the end of that file:

```
sudo python /home/pi/pioneer.py &
```

Save, exit, and disconnect piOneer.

>STEP-10

Get out there!

Ensure that the power switch is in the OFF position and connect the battery to the JST connector. Slowly bring the case edges together, ensuring that *no* metal leads, wires, or solder joints are touching the Pi! Insert a long #6-32 screw through each of the cases's connection lobes and fasten with a nut. We used wing nuts for our fasteners, which makes the case easier to open and close. In order to record a video, just flick the power switch and within 30-45 seconds, piOneer will start recording your slo-mo video. Videos are recorded and saved with a date/time stamp file name. In order to view the videos on your Pi, use:

```
omxplayer date-time-stamp-filename.h264
```

Have fun doing your daredevil deeds, because now you can prove it.

pioneer.py

Language
>PYTHON 3

DOWNLOAD:
magpi.cc/2coG1um

```
import RPi.GPIO as GPIO
from time import sleep
import datetime as dt

import picamera

GPIO.setmode(GPIO.BOARD)
# Set up LED pins
# Ready LED
GPIO.setup(22, GPIO.OUT)
# Countdown 3 LED
GPIO.setup(16, GPIO.OUT)
# Countdown 2 LED
GPIO.setup(15, GPIO.OUT)
# Countdown 1 LED
GPIO.setup(32, GPIO.OUT)
# RECord LED
GPIO.setup(33, GPIO.OUT)
# finisH LED
GPIO.setup(37, GPIO.OUT)

# Camera is ready, begin countdown
GPIO.output(37, False)
GPIO.output(22, True)
sleep(2)
GPIO.output(16, True)
sleep(2)
GPIO.output(16, False)
GPIO.output(15, True)
sleep(2)
GPIO.output(15, False)
GPIO.output(32, True)
sleep(2)
GPIO.output(32, False)
GPIO.output(22, False)

# Begin recording video
GPIO.output(33, True)

# Records 60 seconds of video at 90 fps; change wait_recording
# for length, in seconds, for video
with picamera.PiCamera() as camera:
    camera.resolution = (640, 480)
    camera.framerate = 90
    camera.exposure_mode = 'antishake'
    filename = dt.datetime.now().strftime('%d-%m-%Y-%H:%M:%S.h264')
    camera.annotate_text = dt.datetime.now().strftime('%d-%m-%Y %H:%M:%S')
    camera.start_recording(filename,format='h264')
    start = dt.datetime.now()
    while (dt.datetime.now() - start).seconds < 60:
        camera.annotate_text = dt.datetime.now().strftime('%d-%m-%Y %H:%M:%S')
        camera.wait_recording(0.2)
    camera.stop_recording()

# Finish
GPIO.output(33, False)
GPIO.output(37, True)
sleep(10)
GPIO.output(37, False)

GPIO.cleanup()
```

CREATE SD CARDS WITH ETCHER

You'll Need

- Raspberry Pi
- micro SD card
- Etcher

The easiest way to burn OS image files to your Raspberry Pi SD cards

Copying operating system (typically Raspbian) image files to a micro SD card is an essential part of getting started with a Raspberry Pi. It can be a long-winded process, and is often difficult for newcomers to grasp.

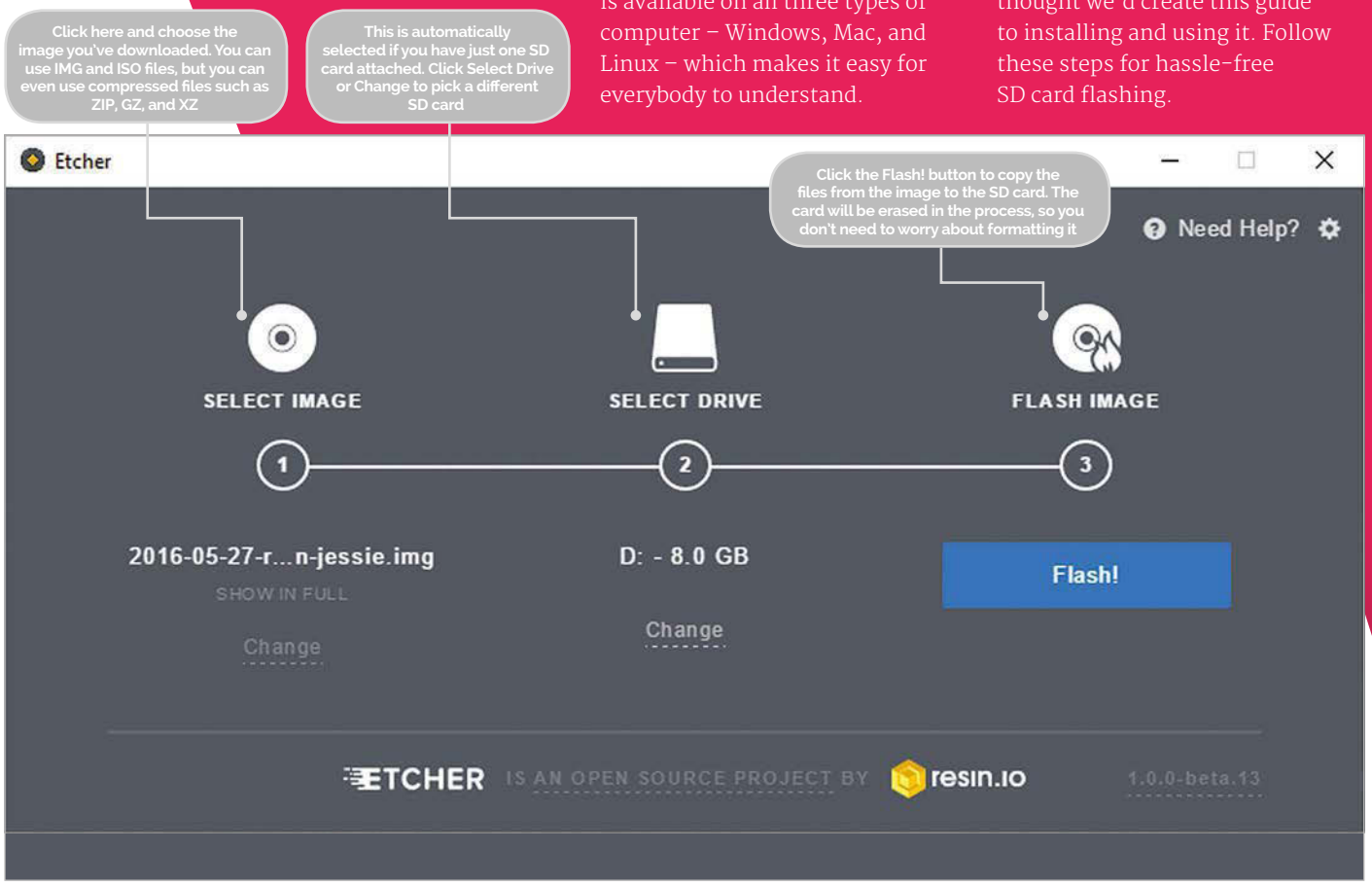
Mac and Linux users typically use the **dd** command in the terminal, while Windows users require a program such as Win32DiskImager.

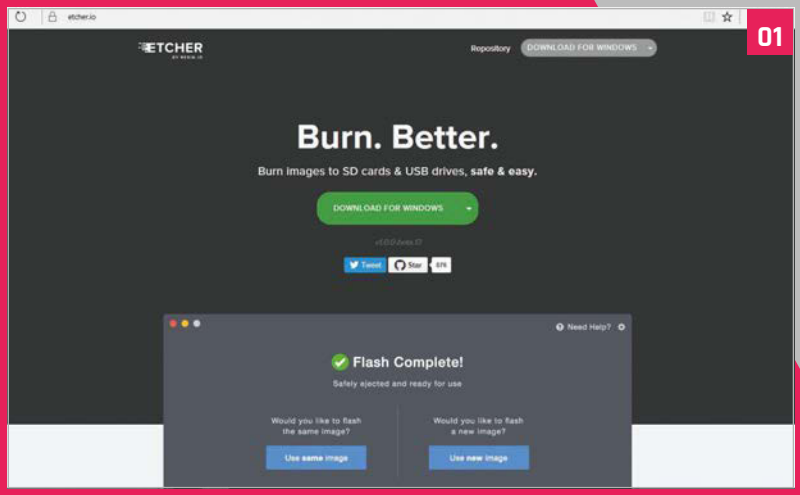
So we were pleased to come across Etcher (**etcher.io**). Etcher turns the whole process of flashing an OS image file into three simple steps: Select Image, Select Drive, and Flash Image.

More importantly, the same program, with the same interface, is available on all three types of computer – Windows, Mac, and Linux – which makes it easy for everybody to understand.

Etcher takes a lot of the stress out of flashing a drive. Etcher won't write to your hard drive volumes unless you check Unsafe Mode in Settings. Unsafe Mode is handy if you want to flash a USB thumb drive or other internal drive, but it's disabled by default, making the process safer for newcomers.

We like Etcher so much, we thought we'd create this guide to installing and using it. Follow these steps for hassle-free SD card flashing.


Click here and choose the image you've downloaded. You can use IMG and ISO files, but you can even use compressed files such as ZIP, GZ, and XZ
This is automatically selected if you have just one SD card attached. Click Select Drive or Change to pick a different SD card
Click the Flash! button to copy the files from the image to the SD card. The card will be erased in the process, so you don't need to worry about formatting it
Etcher
Need Help?
SELECT IMAGE
SELECT DRIVE
FLASH IMAGE
1
2
3
2016-05-27-r...n-jessie.img
SHOW IN FULL
Change
D: - 8.0 GB
Change
Flash!
ETCHER IS AN OPEN SOURCE PROJECT BY resin.io
1.0.0-beta.13


01
ETCHER
Repository
DOWNLOAD FOR WINDOWS
Burn. Better.
Burn images to SD cards & USB drives, safe & easy.
DOWNLOAD FOR WINDOWS
Flash Complete!
Safely ejected and ready for use
Would you like to flash the same image?
Use same image
Would you like to flash a new image?
Use new image

>STEP-01
Install in Windows or Mac

Download and install Etcher from the **etcher.io** website. Double-click the .exe file in Windows and follow the Etcher setup wizard. Drag the Etcher app to your Applications folder on a Mac and double-click to open it. In Windows, run Etcher in Administrator Mode: right-click on Etcher and choose 'Run as administrator'.

>STEP-02
Install on Linux

Download the AppImage file from the Etcher website. Open a terminal window and enter:

```
cd Downloads
chmod a+x Etcher-linux-x64.AppImage
./Etcher-linux-x64.AppImage
```

>STEP-03
Download your OS image

Download a copy of the latest Raspbian image from **raspberrypi.org/downloads** (or the OS image you want to install). Unzip the file after it has downloaded. Double-click the file in Mac or Linux (or use **unzip** in a terminal window). In Windows, right-click the file and choose Extract All. Etcher can install directly from a ZIP file, but the process takes a lot longer.

>STEP-04
Select the image

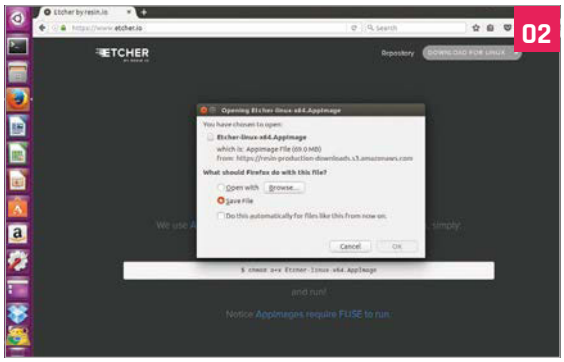
Click **Select Image** in Etcher. Use the file manager window and locate the image you unzipped in the previous step. Click **Open**. The image will appear under Select Image, and **Connect a drive** will highlight red.

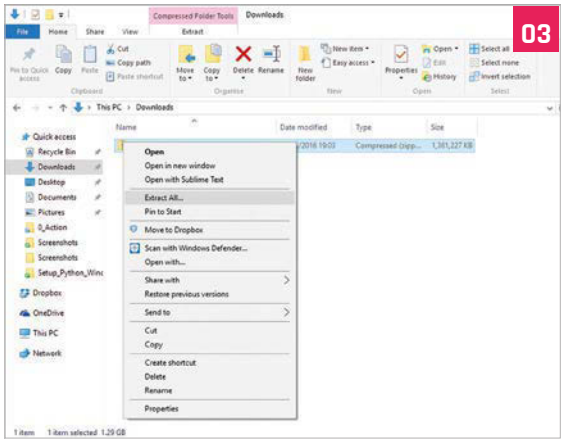
>STEP-05
Insert your SD card

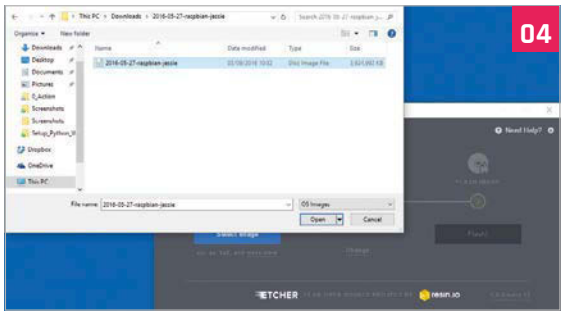
Attach your SD card to the computer. Etcher will select it automatically. Etcher won't write to your hard drives by default, but check that the SD card is listed correctly. Now click **Flash!** to write the image file to the SD card.

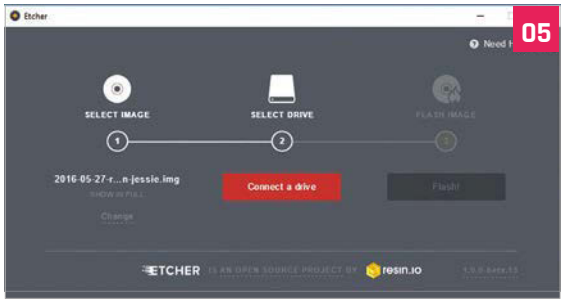
>STEP-06
Writing the image

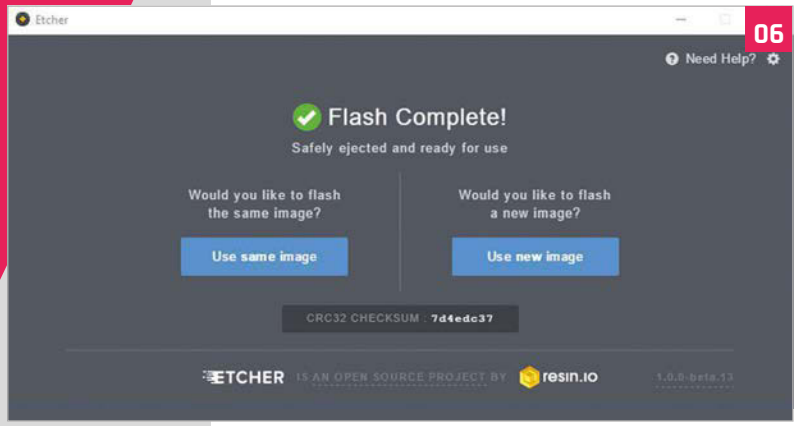
Etcher will format the SD card, before writing and verifying the image; this is shown by a progress bar. When done, remove the SD card, insert it into your Raspberry Pi, and power it up. If you want to flash another SD card with the same image, insert it and click **Use Same Image**.










06
Etcher
Need Help?
Flash Complete!
Safely ejected and ready for use
Would you like to flash the same image?
Use same image
Would you like to flash a new image?
Use new image
CRC32 CHECKSUM : 7d4edc37
ETCHER IS AN OPEN SOURCE PROJECT BY resin.io

SAM AARON

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sonic-pi.net

Sonic Pi PART 14

EIGHT TIPS FOR LIVE-CODING PRACTICE

You'll Need

- Raspberry Pi running Raspbian
- Sonic Pi v2.9+
- Speakers or headphones with a 3.5mm jack
- Update Sonic Pi: `sudo apt-get update && sudo apt-get install sonic-pi`

Practice makes perfect and **Sam Aaron** has some tips on how to do that

Last month, we took a look at five important techniques for mastering live coding; in other words, we explored how we could use Sonic Pi to approach code in the same way we would approach a musical instrument. One of the important concepts that we discussed was practice. This month, we're going to take a deeper dive into understanding why live-coding practice is important and how you might start.

Practise regularly

The most important piece of advice is to make sure you practise regularly. Veterans typically practice for 1–2 hours a day, but 20 minutes is just fine when you're starting out. Little but often is what you're aiming for.

Tip #1 – start to develop a practice routine. Find a nice time in the day that works for you, and try to practise at that time as many days of the week as you can. Before long, you'll be looking forward to your regular session.

Learn to touch-type

If you watch a professional musician performing on stage you'll likely notice a few things. Firstly, when they play they don't stare at their instrument. Their fingers, arms, and bodies know which keys to press, strings to pluck, or drums to hit without them having to think about it too much. This is known as 'muscle memory' and although it might sound like something only professionals can do, it's just the same as when you first learned to walk or ride a bike: practising through repetition.

Tip #2 – learn how to touch-type. There are many apps, websites, and even games to help you achieve this. Find one you like the look of and stick at it until you can code without looking down.

Code whilst standing

The body of a musician is conditioned for playing their instrument. For example, a trumpet player needs to be able to blow hard, a guitar player needs to be able to grip the fretboard with strength, and a drummer needs to be able to continually hit the drums for long periods of time. So, what's physical about live-coding? Just like DJs, live-coders typically perform standing up, and some even dance whilst they code! If you practise live-coding whilst sitting at a desk and then have to get up and stand at a gig, you'll likely find the difference very difficult and frustrating.

Tip #3 – stand while you practise. The easiest way to do this is to use a standing height desk. However, if you don't have one at home there are a couple of low-fi options, such as practising on an ironing board or with a keyboard on a stack of books. Make sure you stretch before you start practising, and try to maybe dance a little during the session.

Practise setting up

Most instruments require some assembly and tuning before they can be played. Unless you're a rock star with a bus full of roadies, you'll have to set up your own instrument before your gig. This is often a stressful time and it's easy for problems to occur. One way to help with this is to incorporate the setup process into your practice sessions.

Tip #4 – treat setting up as an important part of your practice. Pack a box with all the performance essentials and put them together before each practice session. Once you've finished practising, take the time to carefully pack everything away afterwards. This may take some time at first, but with practice you'll get faster.

Experiment musically

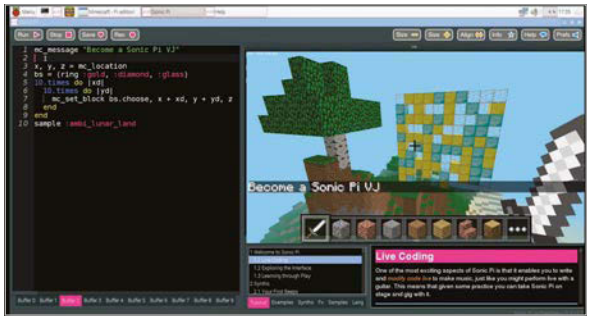
Once you've set up and are ready to start making music, you might find yourself struggling to know where to start. You might have a good idea of the kind of sounds you want to make, but are frustrated that you can't produce them, or you don't even know what kind of sound to make! Don't worry: this is very common and happens to every musician, even if they've been practising for a long time. It's much more important to be making sounds you don't like than not making any sounds at all.

Tip #5 – spend time experimenting. Try to make time to explore new sounds and ideas. Don't worry that it might sound terrible if it's not the style you're looking for. You'll increase the chance of stumbling over a sound or combination of sounds which you love! Even if 99% of the sounds you make are bad, that 1% might be the riff or intro to your new track. Forget the things you don't like and remember the parts you do. This is even easier when making music with code: just press Save!

Hear the code

Many musicians can look at a musical score and hear the music in their head without having to play it. This is a very useful skill and it's well worth incorporating into your live-coding practice sessions, to have some understanding of what the code is going to sound like. You don't need to be able to hear it exactly in your head, but it's useful to know if the code is going to be fast, slow, loud, rhythmic, melodic, random, etc. The final goal is then to be able to reverse this process: to be able to hear music in your head and know what code to write to make it. It may take you a long time to master this, but once you do, you'll be able to improvise on stage and express your ideas fluently.

Tip #6 – write some code into Sonic Pi, but don't press Run. Instead, try to imagine what sound it's going to produce. Then press Run, listen, and think about what you got right and what you didn't. Keep repeating this until it becomes a natural part of your coding process. Even if you're a veteran, you might be surprised occasionally, but it does let you learn new tricks.



Above If you plan to add some Minecraft magic to your set, you should practise that too

MAIN APPLICATION MANIPULATION

- `M-r` - Run Code
- `M-s` - Stop Code
- `M-i` - Toggle Help System
- `M-p` - Toggle Preferences
- `M-{` - Switch Buffer to the Left
- `M-}` - Switch Buffer to the Right
- `M-+` - Increase Text Size of Current Buffer
- `M--` - Decrease Text Size of Current Buffer

Remove all distractions

A common problem when practising is to become distracted with other things. Practising is hard and requires real discipline, regardless of the kind of music you're making. If you're struggling to get started or make progress, it's often too easy to hop on social media; if you've set yourself a target of 20 minutes of practice, it's important to try to spend all that time being as productive as possible.

Above Learn the Sonic Pi shortcuts, and improve your performance, here: magpi.cc/2cO2mCt

Tip #7 – before you start practising, remove as many distractions as possible. For example, disconnect from the internet, put your phone in another room, and try to practise in a quiet place where you're unlikely to be disturbed.

Keep a practice diary

When you're practising, you'll often find your mind is full of new exciting ideas: new musical directions, new sounds to try out, new functions to write, etc. These ideas are often so interesting that you might stop what you're doing and start working on the idea. This is another form of distraction!

Tip #8 – keep a practice diary by your keyboard. When you get an exciting new idea, pause your practice session, quickly jot the idea down, then carry on practising. You can then spend some quality time thinking about and working on your ideas after you've finished practising.

Bringing it all together

Try to establish a practice routine which incorporates as many of these ideas as possible. Keep the sessions as fun as possible, but be aware that some practice sessions will be hard and feel a little like work. However, it will all be worth it once you've created your first piece or given your first performance. Remember, practice is the key to success!

SIMON LONG

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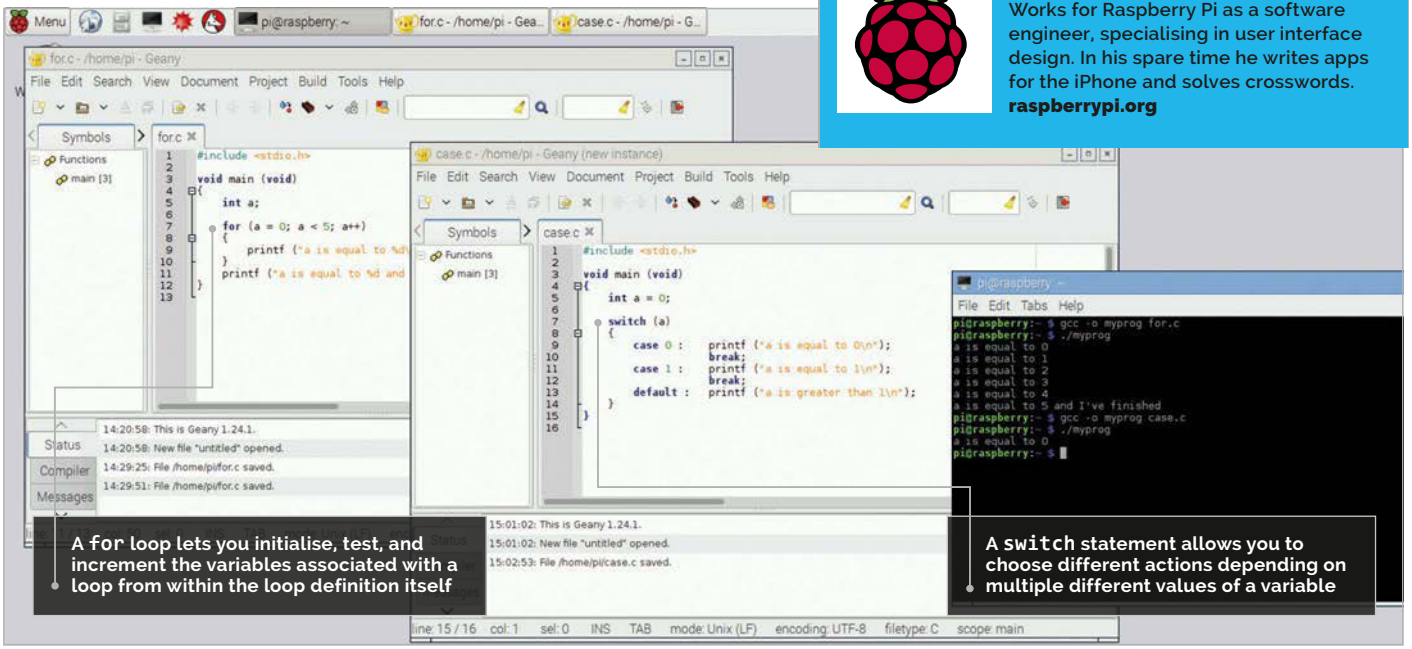
A for loop lets you initialise, test, and increment the variables associated with a loop from within the loop definition itself
A switch statement allows you to choose different actions depending on multiple different values of a variable

AN INTRODUCTION TO C

PART 04

ADVANCED FLOW CONTROL

For loops and case statements – more advanced ways of controlling the flow of a program

The **if** statement and **while** loop described in the previous article are fairly simple control structures. This month, we're going to look at a few more complex ones that can help to make your code shorter and more efficient.

While the **while** loop we saw in the previous article is very useful, the **for** loop tends to be favoured by many programmers, as it puts all the logic controlling the loop in one place. Here's an example:

```
#include <stdio.h>

void main (void)
{
   int a;
   for (a = 0; a < 5; a++)
   {
      printf ("a is equal to %d\n", a);
   }
   printf ("a is equal to %d and I've
     finished", a);
}
```

This isn't all that different from a **while** loop, but all of the control for the loop lives in the round brackets after the **for** keyword. This contains three statements, separated by semicolons; in order, these are the initial condition, the test, and the increment.

a = 0 is the initial condition; the variable **a** is initialised to 0 at the start of the loop.

a < 5 is the test, just like in a **while** loop; this is checked on each iteration of the loop, and the loop code is only executed if the test evaluates to true; as soon as the test is false, execution continues after the curly bracket at the end of the loop code.

a++ is the increment; this is code which is executed at the end of each iteration of the loop, before the test is evaluated again. In this case, it adds 1 to **a**.

So when this **for** loop runs, what happens? First, **a** is set to 0. The test is then checked; is **a** (which is 0) less than 5? Yes it is, so the code inside the curly brackets is executed, and the value of **a** is printed. Finally, the increment is applied, meaning 1 is added to **a**.

The test is then repeated; if true, the loop code is executed again, and the increment is again applied, then this repeats over and over until the test is false. In terms of what they do, **for** loops and **while** loops are pretty much identical.

Switch statements

One thing that you quite often want to do is to test a variable against several values and do different things based on each of them. You can do this with a set of nested **if** statements:

YOUR FAVOURITE LOOP...

All three types of loop in C – **while**, **do-while**, and **for** – can be used in nearly every situation where a loop is needed; choose whichever you like. Some people prefer to use one type of loop for everything; others pick and choose whichever looks tidiest for each circumstance. There are no wrong choices!

```
#include <stdio.h>

void main (void)
{
   int a = 0;
   if (a == 0)
   {
      printf ("a is equal to 0\n");
   }
   else if (a == 1)
   {
      printf ("a is equal to 1\n");
   }
   else
   {
      printf ("a is greater than 1\n");
   }
}
```

That does start to get pretty long-winded though, so C provides a neater way of doing this, called a **switch** statement.

```
#include <stdio.h>

void main (void)
{
   int a = 0;
   switch (a)
   {
      case 0 : printf ("a is equal to 0\n");
               break;
      case 1 : printf ("a is equal to 1\n");
               break;
      default : printf ("a is greater
                than 1\n");
   }
}
```

This does exactly the same as the example above with multiple **if** statements, but is a lot shorter.

The opening line consists of the keyword **switch**, with the name of a variable in round brackets; this variable will be tested against the various cases.

The body of the switch statement is a number of **case** statements. The variable **a** is compared against each case in turn; if it matches the value just after the word **case**, then the lines of code after the colon are executed.

The final case is just called **default**; every switch statement should include a default case as the final one in the list, and this is the code which is executed if none of the other cases match.

Notice that the last line in each case section is the word **break**; this is very important. This keyword tells the compiler that you want to 'break out' of the switch statement at this point; that is, to stop executing code inside the switch. If you forget to include the break statements, every case after the one you wanted will also execute. Try it by compiling the code above and running it; in the terminal you'll see it say that **a is equal to 0**. Now remove the two break statements:

```
switch (a)
{
       case 0 : printf ("a is equal to 0\n");
       case 1 : printf ("a is equal to
                    1\n");
       default : printf ("a is greater
                    than 1\n");
}
```

...and run it again – you'll now see:

```
a is equal to 0
a is equal to 1
a is greater than 1
```

Not what you expected! This is another common bug in C code; forgetting the break statements in your cases can result in very unexpected behaviour.

Leaving a loop early

The **break** statement has one other use; it can be used inside **while** and **for** loops to break out of them. Look at this example:

```
#include <stdio.h>

void main (void)
{
 int a = 5;
 while (1)
 {
    printf ("a is equal to %d\n", a);
    a++;
    if (a == 5)
    {
       break;
    }
 }
 printf ("a is equal to %d and I've
    finished", a);
}
```

So we have a **while** loop in which the test is just the value 1; this is a non-zero value, so is always true. If you enclose code inside curly brackets after a **while (1)** statement, the loop will never end; it will keep running for ever. But in this case we've provided an alternative way to end the loop. We test the value of **a** inside the loop itself in an **if** statement, and if **a** is equal to 5, we call the **break** command; this causes the loop to end and execution to continue with the statement after the loop. A **break** statement like this can be useful to leave a loop early in the event of an error, for example.

MULTIPLE INITIALISATIONS

You can initialise multiple variables in a `for` loop – just separate them by commas. So if you want to set two variables at the start of the loop, you can use `for (a = 0, b = 1;<test>; <increment>)`

MULTIPLE INCREMENTS

As with multiple initialisations, you can have multiple increments in a `for` loop, also separated by commas – `for (a = 0; b = 1; <test> ; a++, b *= 2)`. This is useful if there are two or more variables that change consistently while the loop runs.

CONTINUE

The keyword `continue` can be used in a loop instead of `break`. Instead of breaking out of the loop, however, `continue` skips all the rest of the code in the current iteration, and returns to the test case at the start of the loop. Among other things, this can be useful to speed up your code.

MIKE'S PI BAKERY

MIKE COOK

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magpi.cc/259aT3X

DANSE MACABRE
THE SKELETON DANCE

Make a skeleton dance to your music in front of the fires of hell, for Halloween

You'll Need

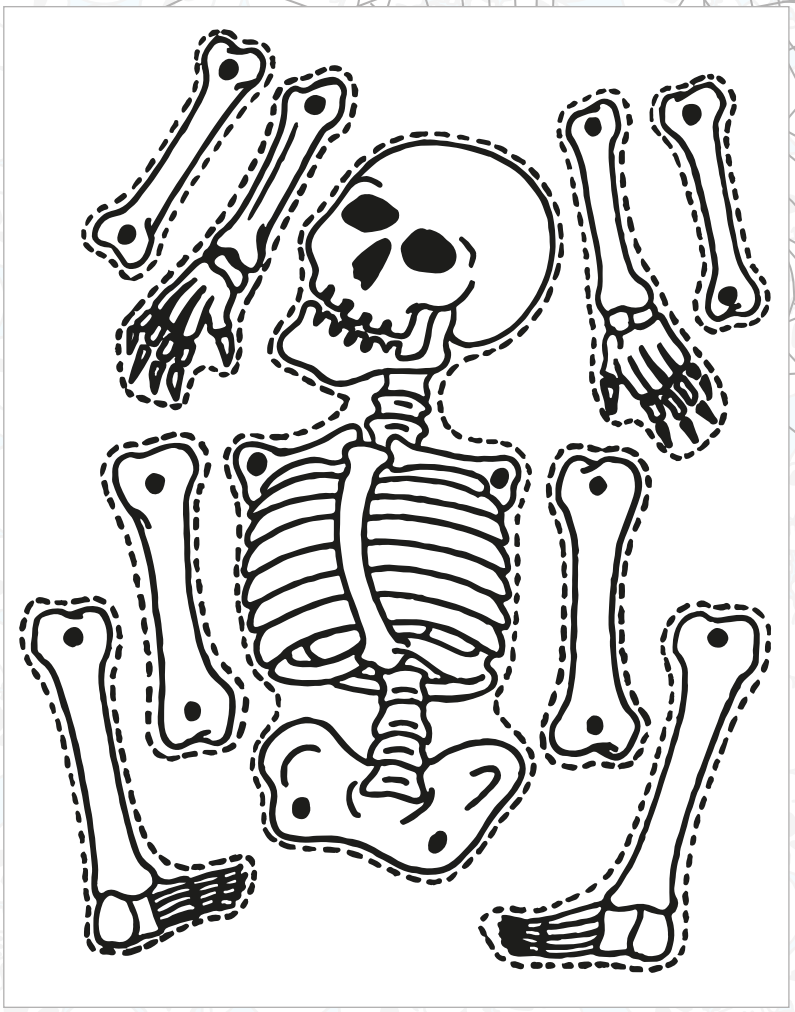
- Spectrum display hardware (see *The MagPi* #46)
- Or thumb joysticks (see *The MagPi* #49)

The *Danse Macabre* is a piece of classical music created in 1874 by the French composer Camille Saint-Saëns. It's often known by the popular name of 'The dance of the skeletons' and it inspired this year's Halloween project. We've used the hardware from our Spectrum display project in *The MagPi* issue 46 to get data from sound, which is then used to make an animated skeleton dance to the music. Alternatively, there's a version that uses last month's twin joystick interface. So there's no new hardware this month, but quite a bit of software, so let's see what we need.

Building your marionette

The idea is to take an image of each component of a skeleton and draw it on the screen so that each component links up together. However, like any marionette, the limbs aren't fixed but jointed. In computing terms, this involves plotting each limb in a specific rotational orientation. This presents us with a problem, because the CPU power needed to rotate an image is a bit heavy, even for a computer as powerful as the Raspberry Pi. What's more, a simple rotation often leaves the image with jagged artefacts that change with the rotation, making

any resulting animation look fuzzy and noisy. The solution to this is to rotate a much higher-resolution image and then scale it down to the size you want. Unfortunately, this adds even more to the burden on the CPU. So, to get over this, the images of the various limbs are precalculated. We've used this technique on several occasions before, for example in the Olympic Swimming Simulator of *The MagPi* #48. Each frame was prepared beforehand, then loaded into the program at runtime. We initially tried the same technique with our skeleton, but it soon became clear that not only was this tricky to do in the graphics package, but also a lot of images needed creating. In addition, for each image, you need data saying where the plot and connection points are for that image. We thought, like the Little Princess said, "there must be something better", and so we let the program generate all the intermediate images from the one starting prototype image. The only downside to this is the amount of time it takes to initialise the program at the start.



Graphics

If you search the internet for 'cut out skeleton', you'll find a wide variety of graphics designed to be printed onto card, cut out, and then assembled using paper fasteners as joints. We chose the one shown in **Fig 1**, and set about cutting it up in a graphics package. Each limb was isolated and made into a single image on a transparent background. We used the same image for the upper arm bone and thigh bone, and just

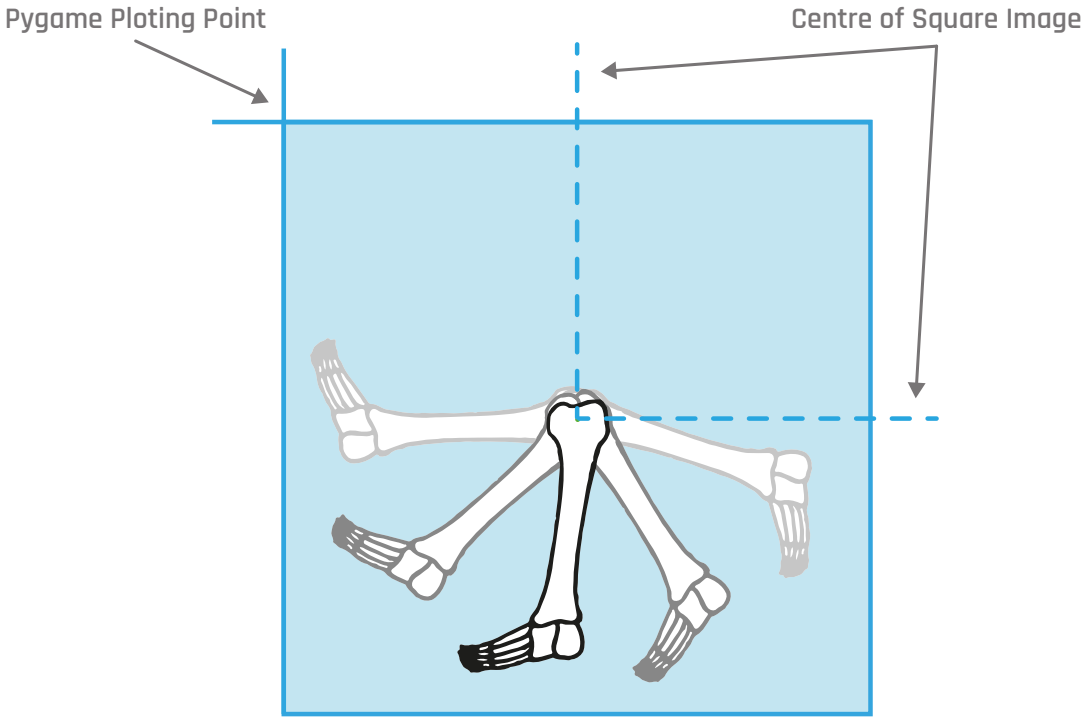


Fig 1 The original cut-out skeleton

Fig 2 Plotting of an outer limb is in the same location despite any rotation

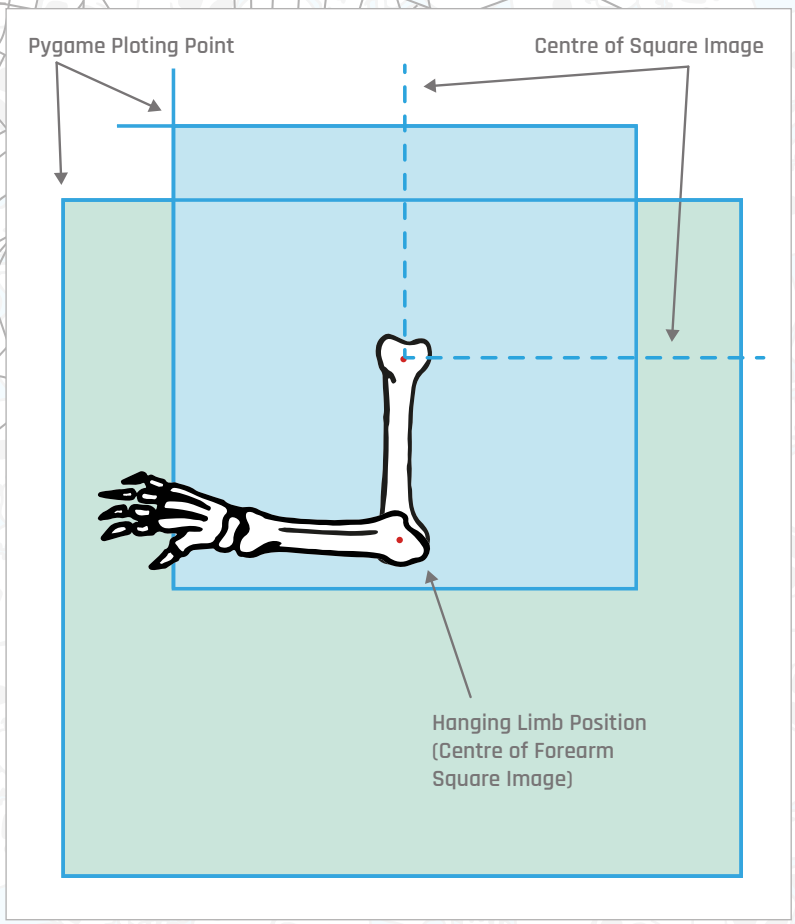


Fig 3 Hanging an outer limb on an inner limb

used the same image flipped for the two forearms. All the images, with the exception of the body, were made square with the pivot point at the centre. Any other pivot points on the image were noted using the pointer position window in the graphics package. Each part was kept at a large size and scaled down by 33% in the Python software. The exception to this was the body: as this didn't need rotating, it was scaled down directly in the graphics package.

> "The idea is that each limb rotation, and the skeleton's position on the screen, is controlled by one of the music channels from the Spectrum hardware"

Graphics strategy

So, each limb has a single image associated with it. This image is on a transparent background, but the key to making it work is that the joint, or plotting position, of the limb is at the centre of the image. That way, we can rotate it around the centre but still draw it in the same place independently of the rotation – see **Fig 2**. Now, Pygame uses the top-left corner of an image for its plotting position and with this way of drawing the image, the plotting point we want to use – the centre of the image – is simply offset by half the width, or height, of this square image.

While that's fine for the end limbs, there's another problem for limbs that need another limb hanging off them. Fortunately, this has a simple solution. You just need to have the pixel coordinates of this point and as you rotate the image round the centre point, you also rotate these coordinates and save them in a list corresponding to each rotation position. This list is the plotting position of the hanging limb and is used to determine where in the Pygame window to plot it. This is shown in **Fig 3** – note how most of the image is just a transparent background.

All these limbs are hung off a body image. This will have some x-y position in the Pygame window, and there are pivot points that are relative to the body image. To find the place to plot an inner limb (an arm or thigh), you have to add the x-y position to the pivot point offset. Now, to find the place to plot the outer limb, you add the appropriate offset from the list of outer limb hanging positions. This is shown in **Fig 4** and while it may seem complex, the place to plot the outer limbs is found by building up the relevant offsets.

Software

A program that just tests out the skeleton's limb movement is on our GitHub repository and is a subset of the full **dance.py** code shown overleaf. The idea is that each limb rotation, and the skeleton's position on the screen, is controlled by one of the music channels from the Spectrum hardware. This has left and right stereo information and, basically, this is used to control the left and right side of the skeleton. This gives a mainly symmetrical look to the movement. However, the snag is that with no sound on a channel, we wanted some limbs to be at the middle point of their rotation range. So we had to see if there was a zero or small value in the data channel and if so, set the limb to the centre point. The data from the Spectrum hardware is scaled into a floating point list, with values between 0.0 and 1.0; this is called a normalised number. The skeleton's x-y position on the screen is controlled by the difference between left and right channels of the lower frequencies. This kept the movement from being too jerky across the screen.

To make the software easier to follow, each limb rotational position is defined by its own variable.

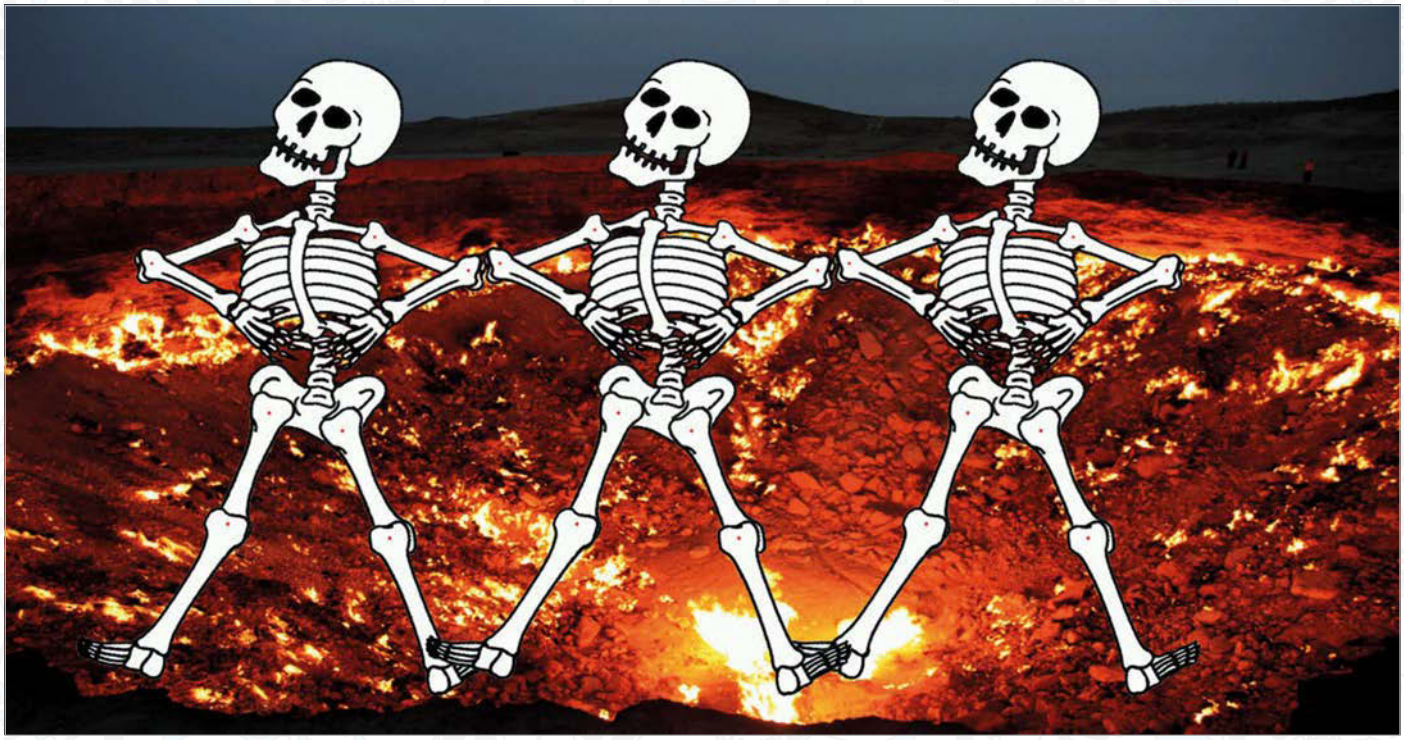


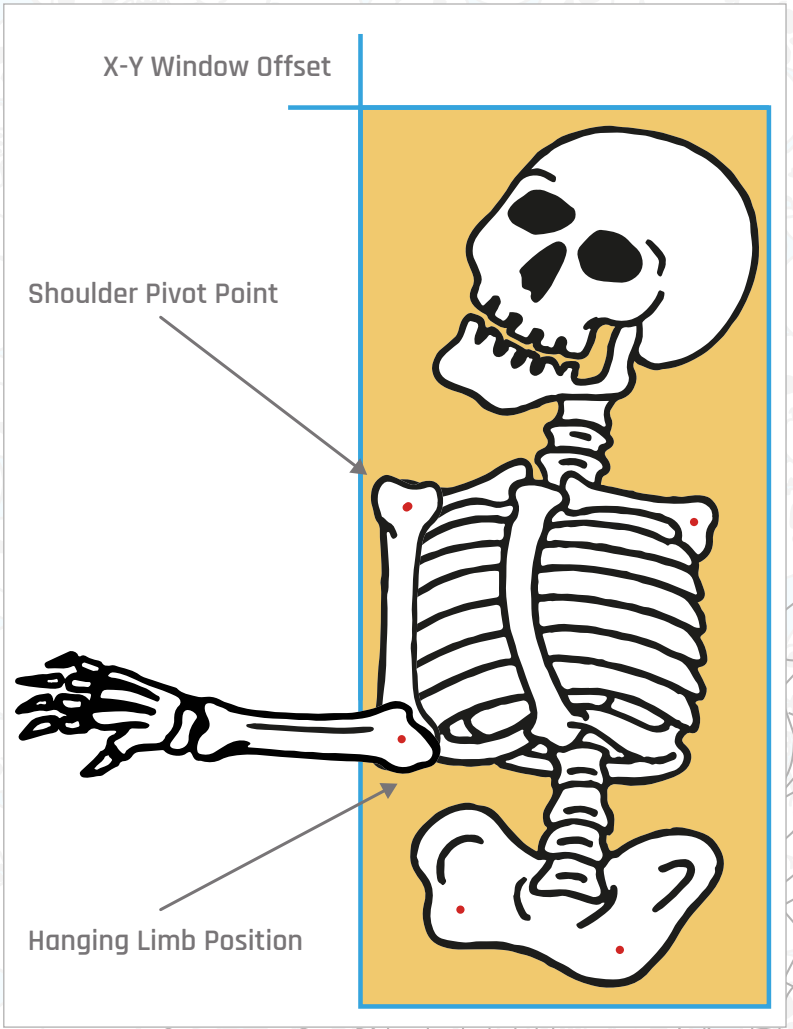
Fig 5 A trio of dancing skeletons

A more compact way would be to use a list to mop up the repeated code in the main loop. As it takes about a minute to create and rotate all the images, progress is printed out on the console. Since the program runs in fullscreen mode, however, this is obscured, so in order to see the progress, the fullscreen window is iconified. Unfortunately, there is no un-iconify command and so the user is prompted to click on the icon bar when the code is ready to display. The space bar will toggle between a full-size window with icon bar and a full screen. The skeleton dances in front of a picture of a real-life pit of hell in Turkmenistan, which has been burning for over 50 years. You'll find that if the volume is too loud, then the skeleton bunches up; if too quiet, it doesn't move much.

Taking it further

We restricted the limb movements to what we considered realistic, although there is a certain suspension of disbelief with the concept of a dancing skeleton anyway. You can easily change the limb rotation to the full 360 degrees to get far more crazy positions. There's lots to tinker about with regarding the mapping of the sound to the movement. Also, there's a manual version in the GitHub repo that uses the twin thumb joystick from last month's project. How about having two skeletons that dance in perfect synchronisation? Or have each one with its own unique mapped data so they're different? In fact, we have produced two- and three-skeleton versions that you can find on GitHub as well. These seem to be even funnier than the solo skeletons – see **Fig 5**. By having more than one skeleton, the moves seem more choreographed.

Fig 4 Joining limbs to the body



dance.py

```
01. import pygame, time, os, math
02. from pygame.locals import *
03. import wiringpi2 as io
04.
05. pygame.init()          # initialise graphics interface
06. screen = pygame.display.set_mode((0, 0))
    # with window bar - use for debugging
07. pygame.display.iconify() # hide window
08. xPovitBodyLarm = 17   ; yPovitBodyLarm = 153
09. xPovitBodyLleg = 37   ; yPovitBodyLleg = 306
10. xPovitBodyRarm = 126  ; yPovitBodyRarm = 159
11. xPovitBodyRleg = 98   ; yPovitBodyRleg = 322
12. xPovitBodyThighL = 37 ; yPovitBodyThighL = 306
13. xPovitBodyThighR = 98 ; yPovitBodyThighR = 321
14. noiseFloor = [[200, 200, 200, 200, 200, 200, 200],
    [200, 200, 200, 200, 200, 200, 200]]
15. leftData = [ 0.1,0.1,0.1,0.1,0.1,0.1,0.1 ]
16. rightData = [ 0.1,0.1,0.1,0.1,0.1,0.1,0.1 ]
17.
18. def main():
19.     print"Danse Macabre skeleton initialising"
20.     initGPIO()
21.     loadImages()
22.     initWindow()
23.     xbase =((xs/2.2)-100.0)
24.     print"Now click on iconified Danse tab"
25.     print"the space bar controls full screen display"
26.     foreArmMax = 36; ArmMax = 36
27.     thighMax = 40; legMax = 36
28.     moveThresh = 0.08
29.     while True:
30.         getSpectrumData()
31.         pan = int(xbase+float(xs/16)*(leftData[0]-rightData[0]))
32.         tilt = int((ys/4)*(leftData[1]-rightData[1]))+40
33.         ArmPosL = ArmMax/2
34.         if rightData[2] > moveThresh:
35.             ArmPosL = int(float(ArmMax/2) + float(ArmMax)*(
    leftData[2]-0.5))
36.         foreArmPosL = int(float(foreArmMax/2) + float(
    foreArmMax)*(leftData[3]-0.5))
37.         thighPosL = thighMax/2
38.         if leftData[4] > moveThresh:
39.             thighPosL = int(float(thighMax/2) + float(thighMax)*(
    leftData[4]-0.5))
40.         legPosL = legMax/2
41.         if leftData[5] >moveThresh:
42.             legPosL = int(float(legMax/2) + float(legMax)*(
    leftData[5]-0.5))
43.
44.         ArmPosR = ArmMax/2
45.         if rightData[2] >moveThresh:
46.             ArmPosR = int(float(ArmMax/2) + float(ArmMax)*(
    rightData[2]-0.5))
47.         foreArmPosR = int(float(foreArmMax/2) + float(
    foreArmMax)*(rightData[4]-0.5))
48.         thighPosR = thighMax/2
49.         if rightData[3] > moveThresh:
50.             thighPosR = int(float(thighMax/2) + float(thighMax)*(
    rightData[3]-0.5))
51.         legPosR = legMax/2
52.         if rightData[5] >moveThresh:
53.             legPosR = int(float(legMax/2) + float(legMax)*(
    rightData[5]-0.5))
54.
55.         showPicture(ArmPosL,ArmPosR,foreArmPosL,foreArmPosR,
    thighPosL,thighMax-thighPosR-1,legPosL,legPosR,pan,tilt)
56.         checkForEvent()
57.
58. def getSpectrumData():
59.     global leftData, rightData
60.     io.digitalWrite(pinReset,1)
61.     io.digitalWrite(pinClock,1)
62.     time.sleep(0.001)
63.     io.digitalWrite(pinClock,0)
64.     time.sleep(0.001)
65.     io.digitalWrite(pinReset,0)
66.     io.digitalWrite(pinClock,1)
67.     time.sleep(0.004)
68.     for s in range(0,7):
69.         io.digitalWrite(pinClock,0)
70.         time.sleep(0.004) # allow output to settle
71.         leftData[s] =  scaleReading(io.analogRead(70),s,0)
72.         rightData[s]=  scaleReading(io.analogRead(71),s,1)
73.         io.digitalWrite(pinClock,1)
74.
75. def showPicture(armLpos,armRpos,farmLpos,farmRpos,thighRpos,t
    highLpos,legLpos,legRpos, x,y):
76.     #pygame.draw.rect(screen,(0,0,0),(0,0,xs,ys),0)
        # fast alternative to background plot
77.     screen.blit(background,(0,0))
78.     screen.blit(bodyFrame,(x,y))
79.     screen.blit(thighFrames[thighRpos],(
    x - thighPlot+xPovitBodyThighR,y-thighPlot+yPovitBodyThighR))
80.     screen.blit(rightLegFrames[legRpos],(
    x - rightLegPlot + xPovitBodyThighR+dXthigh[thighRpos],
    y-rightLegPlot+yPovitBodyThighR+dYthigh[thighRpos]))
81.
82.     screen.blit(thighFrames[thighLpos],(
    x - thighPlot+xPovitBodyThighL,y-thighPlot+yPovitBodyThighL))
83.     screen.blit(leftLegFrames[legLpos],(
    x - leftLegPlot + xPovitBodyThighL+dXthigh[thighLpos],
    y-leftLegPlot+yPovitBodyThighL+dYthigh[thighLpos]))
84.
85.     screen.blit(armFramesL[armLpos],(
    x - armPlot+xPovitBodyLarm,y-armPlot+yPovitBodyLarm))
86.     screen.blit(foreArmFramesL[farmRpos],(
    x - foreArmPlot + xPovitBodyLarm+dXarmL[armLpos],
    y-foreArmPlot+yPovitBodyLarm+dYarmL[armLpos]))
87.
88.     screen.blit(armFramesR[armRpos],(
    x - armPlot+xPovitBodyRarm,y-armPlot+yPovitBodyRarm))
89.     screen.blit(foreArmFramesR[farmRpos],(
    x - foreArmPlot+xPovitBodyRarm+dXarmR[armRpos],
    y-foreArmPlot+yPovitBodyRarm+dYarmR[armRpos]))
90.     pygame.display.update()
91.
92. def loadImages():
93.     global foreArmFramesR,foreArmFramesL,foreArmPlot,
    armFramesR,armFramesL,armPlot,dXarmR,dYarmR,dXarmL,dYarmL
94.     global thighFrames, thighPlot, dYthigh, dXthigh,
```

Language
>PYTHON 2.7

DOWNLOAD:
magpi.cc/1NqJjmV

PROJECT VIDEOS

Check out Mike's Bakery videos at:
magpi.cc/1NqJnTz

```
    leftLegFrames, leftLegPlot,rightLegFrames, rightLegPlot, bodyFrame
    print"creating and scaling images"
    bodyFrame  = pygame.image.load(
"skImages/body.png").convert_alpha()
    print"creating legs"
    leftLegFrames = [ pygame.transform.smoothscale(
rot_center(pygame.image.load(
"skImages/leftLegzero.png").convert_alpha(),angle),(360,360))
                  for angle in range(90,-90,-5)]
    leftLegPlot = leftLegFrames[0].get_width()/2
    rightLegFrames = [ pygame.transform.smoothscale(
rot_center(pygame.image.load(
"skImages/rightLegzero.png").convert_alpha(),angle),(360,360))
                  for angle in range(-90,90,5)]
    rightLegPlot = rightLegFrames[0].get_width()/2

    print"creating thighs"
    thighFrames = [ pygame.transform.smoothscale(
rot_center(pygame.image.load(
"skImages/thighzero.png").convert_alpha(),angle),(267,267))
                  for angle in range(100,-100,-5)]
    thighPlot = thighFrames[0].get_width()/2
    dYthigh = [ 101.56*math.cos(math.radians(
angle))  for angle in range(100,-100,-5)]
    dXthigh = [
101.56*math.sin(math.radians(angle))  for angle in
range(100,-100,-5)]

    print"creating arms"
    armFramesR = [ pygame.transform.smoothscale(
rot_center(pygame.image.load(
"skImages/armzero.png").convert_alpha(),angle),(224,224))
                  for angle in range(150,-30,-5)]
    armPlot = armFramesR[0].get_width()/2
    dYarmR = [ 85.2*math.cos(
math.radians(angle))  for angle in range(150,-30,-5)]
    dXarmR = [ 85.2*math.sin(
math.radians(angle))  for angle in range(150,-30,-5)]
    armFramesL = [ pygame.transform.flip(armFramesR[i], True,False)
                  for i in range(0,36)]
    dYarmL = [ 85.2*math.cos(
math.radians(angle))  for angle in range(150,-30,-5)]
    dXarmL = [ -85.2*math.sin(
math.radians(angle))  for angle in range(150,-30,-5)]

    print"creating forearms"
    foreArmFramesL = [ pygame.transform.smoothscale(rot_
center(pygame.image.load("skImages/forearmzero.png").convert_
alpha(),angle),(334,334))
                  for angle in range(60,240,5)]
    foreArmPlot = foreArmFramesL[0].get_width()/2
    foreArmFramesR = [  pygame.transform.flip(foreArmFramesL[i],
True,False)
                  for i in range(0,36)]

def rot_center(image, angle):
    """rotate an image while keeping its center and size"""
    orig_rect = image.get_rect()
    rot_image = pygame.transform.rotate(image, angle)
    rot_rect = orig_rect.copy()
    rot_rect.center = rot_image.get_rect().center
    rot_image = rot_image.
subsurface(rot_rect).copy()
    return rot_image

def initWindow():
    global screen,xs,
ys,debug,fullScreen,background
    debug = True
    os.environ['SDL_VIDEO_WINDOW_
POS'] = 'center'
    xs, ys = screen.get_size()
    fullScreen = False
    if not debug :
        pygame.display.toggle_fullscreen()
        fullScreen = True
    pygame.display.set_caption("Danse Macabre")
    pygame.event.set_allowed(None)
    pygame.event.set_allowed([pygame.KEYDOWN,pygame.QUIT])
    background = pygame.transform.smoothscale(pygame.image.
load("skImages/background.jpg"),(xs,ys))

def scaleReading(reading,band,side):
    reading -= noiseFloor[side][band]
    if reading <0 :
        reading = 0
    scaled = (float(reading) / (
1024.0 - float(noiseFloor[side][band])))
    return scaled

def initGPIO():
    global pinReset,pinClock
    pinReset = 23
    pinClock = 24
    try :
        io.wiringPiSetupGpio()
    except :
        print"start IDLE with 'gksudo idle' from command line"
        os._exit(1)
    io.pinMode(pinReset,1)
    io.pinMode(pinClock,1)
    io.mcp3002Setup(70,0)

def terminate(): # close down the program
    print "Closing down please wait"
    pygame.quit() # close pygame
    os._exit(1)

def checkForEvent(): # see if we need to quit
    global fullScreen
    event = pygame.event.poll()
    if event.type == pygame.QUIT :
        terminate()
    if event.type == pygame.KEYDOWN :
        if event.key == pygame.K_ESCAPE :
            terminate()
        if event.key == pygame.K_SPACE:
            pygame.display.toggle_fullscreen()
            fullScreen = not fullScreen
# Main program logic:
if __name__ == '__main__':
    main()
```

IOANA CULIC

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wyliodrin.com

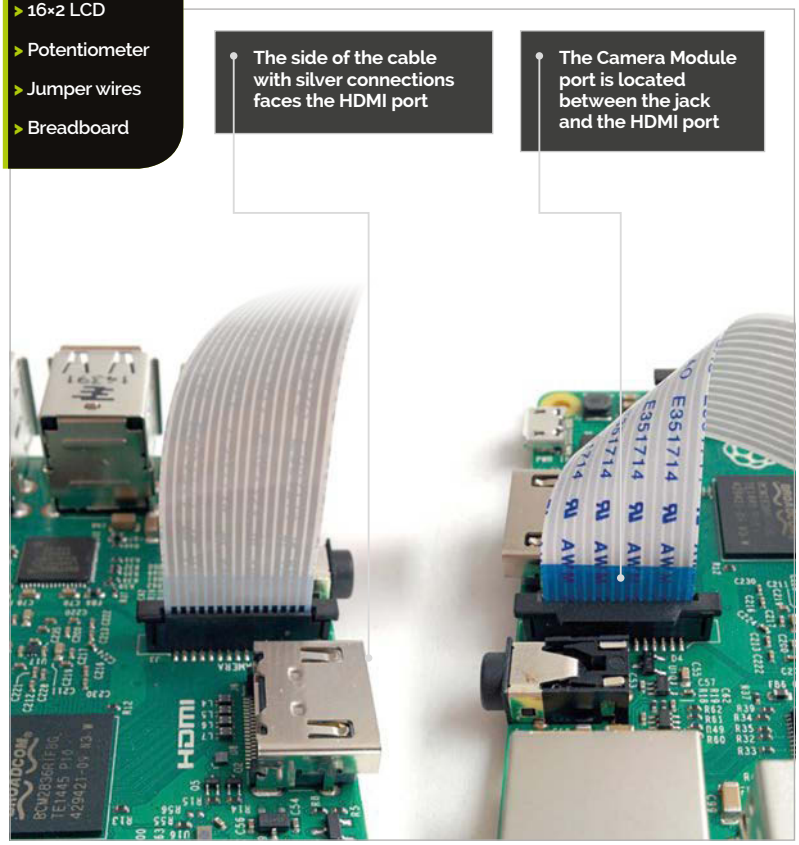
BUILD A CAR MONITORING SYSTEM PART 02

Following on from last issue's tutorial, we use a Camera Module to recognise the number plates of the cars passing by

You'll Need

- Wyliodrin STUDIO **magpi.cc/1Q5j4jl**
- SS441A Hall sensor
- Camera Module
- 220Ω resistor
- 16×2 LCD
- Potentiometer
- Jumper wires
- Breadboard

It's time to take the previously built traffic monitoring system and spice it up by making it really smart. We'll connect it to the internet and, by accessing an open-source image processing service, we'll display the number plate of the detected car. The project is built on top of the one described in the previous issue of the magazine, simply by adding the Camera Module.


The side of the cable with silver connections faces the HDMI port
The Camera Module port is located between the jack and the HDMI port

>STEP-01

Connect the Camera Module

First of all, we will start with the previously built system that detects cars passing by using the Hall sensor (see issue 49 of *The MagPi*). The next step is to connect the camera in order to take a picture of each car passing by the sensor.

The Raspberry Pi board has a port specially designed to connect the camera. It's located between the HDMI port and the 3.5mm headphone jack. We need to place the side of the cable with the silver connections towards the HDMI side of the port.

>STEP-02

Create an OpenALPR account

For this application, we'll use a web service in order to extract the number plate from the pictures taken with the Pi Camera. The web service is OpenALPR; it allows us to upload pictures and get details such as the car model, colour, and licence plate.

In order to use the service, we need to create an account on **openalpr.com**, which requires a valid email address. We have to confirm the email address, then we can log in and use the service.

Edit python node

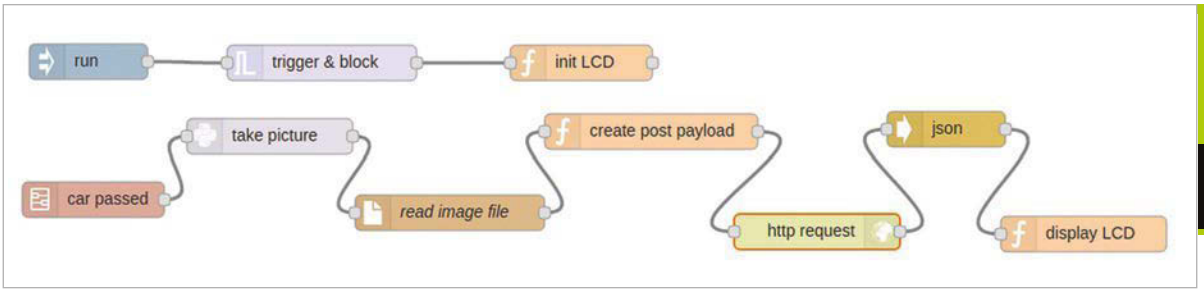
Function

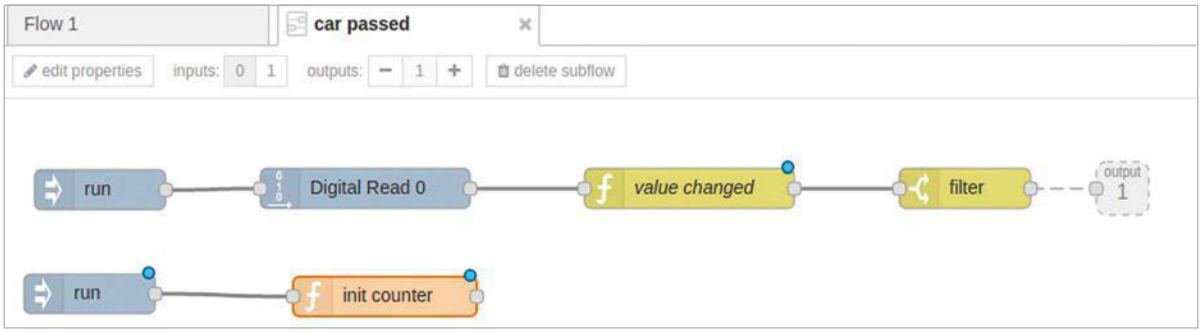
```
1  from picamera import PiCamera
2  from time import sleep
3
4  camera = PiCamera()
5  camera.start_preview()
6  sleep(5)
7  camera.capture('/home/pi/image.jpg')
8  camera.stop_preview()
9
```

Above We use Python code to take a picture of the passing car

Language
>STREAMS (NODE-RED)

DOWNLOAD:
magpi.cc/2blRrtf





Top-left Here's the new code for this part of the tutorial

Left The previously created code can be copied to a subflow, creating a new node

Once logged in, we go to Cloud API and check the Cloud API credentials. We will need the secret key later on.

>STEP-03
Update the application

We will start with the **streams** application that we created previously.

To make the code more modular, we'll create our own new subflow. Go to the Options menu in the top-right of the workspace and select **Subflows > Create Subflow**. Once the subflow is created, we select the **edit properties** option and name it **`car passed`**. We also set the number of outputs to 1.

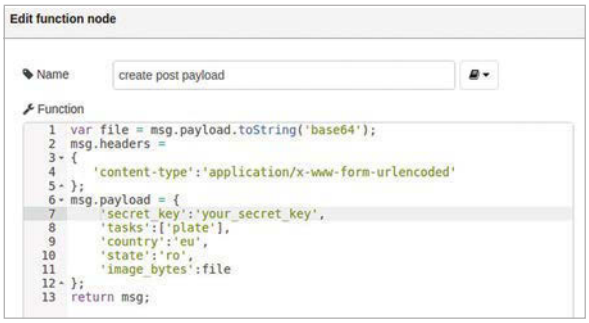
The code we have to insert in the subflow is the one created in the previous article, except the counter, which is missing. The final behaviour is that each time a car passes, the node outputs a message.

>STEP-04
Take a picture of the car

The node connected to **`car passed`** is a Python node. It's similar to the function node, but it allows us to write code in Python instead of JavaScript. The Python code initialises the connection to the Pi camera, waits for five seconds to finish initialising and calibrating the camera, then it takes the picture and stores it as **/home/pi/image.jpg**.

The piece of code uses the PiCamera module. However, this module is not installed on the Pi by default. In order to install it, we need to open a terminal window and type the following command:

```
sudo pip install picamera
```



Above The HTTP request payload must contain the picture file

>STEP-05
Recognise the number plate

Once the picture is saved, we'll access a web service to process it. The **`read image file`** node parses the file and, further on, sends a message storing the file's contents in a **`buffer`**.

Next, we send a POST request to OpenALPR. For this, we use a function node. There, we store the image file in a variable under Base64 encoding, then we create a new payload consisting of a JSON structure.

The JSON asks for the **`secret_key`** and for a list of processing tasks you need the service to do. After the payload is created, it goes to the **`http request`** node, which will do a POST request at the following address: **api.openalpr.com/v1/recognize.**

>STEP-06
Print the number plate

The request returns a JSON structure under a string format. We use the JSON node to obtain a structure containing the **`plate.results`** property. That is a list of possible plate numbers, the first element being the most likely to be correct.

Next, we create a function to extract the first element of the list and get the **`plate`** property. That is a string representing the plate number. We use the **`print`** function to display it on the LCD.

We can test the prototype by placing a picture of a number plate in front of the camera, while passing a magnet next to the Hall sensor.

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@RaspberryCoulis

BUILD YOUR OWN RASPCADE: CABINET ASSEMBLY!

You'll Need

- RaspCade designs (**magpi.cc/21jHT61**)
- Access to a laser cutter
- Wood glue (DIY store)
- 2× 3-inch, 4Ω, 3W speakers (**ModMyPi.com**)
- 8× countersunk M4 nuts and bolts
- A drill with a countersink head
- Various 12.7mm standoffs (**ModMyPi.com**)
- 2× small jewellery box hinges

In this fourth part of the build, we'll be showing you how to assemble your laser-cut cabinet as part of your RaspCade home arcade machine

RaspCade
The cabinet simply slots together and is held firm with some strong wood glue
We've designed this cabinet so it can be laser cut quickly and without breaking the bank!

In the first part of our build, we talked about our custom-designed RaspCade cabinet so that you could download the designs and laser cut your own. In this guide, we will look at this in more detail and provide an overview of assembling our RaspCade, so that we can take a giant step towards playing our retro video games. We'll also look at adding speakers to our RaspCade and mounting all our kit inside in preparation for the next edition, where we'll finally get our arcade machine up and running!

>STEP-01

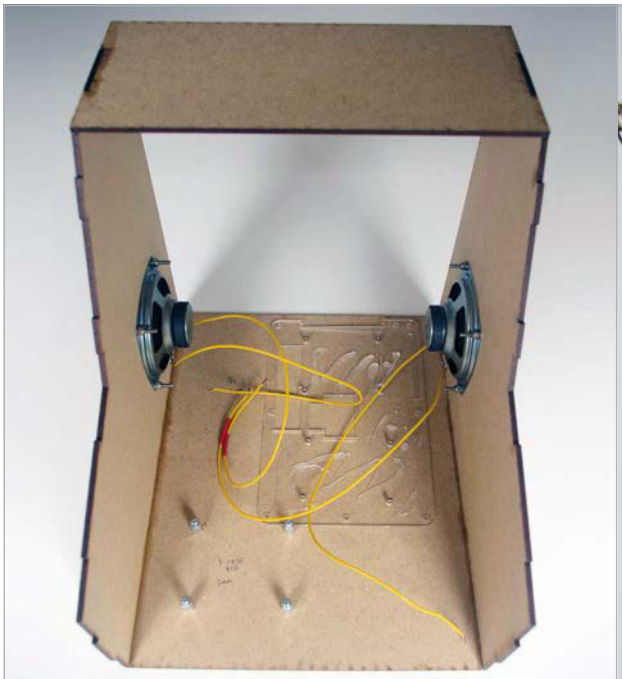
Our RaspCade designs

You're going to need a laser-cut RaspCade to get started, but we designed one so you don't have to. Designed in Adobe Illustrator and saved as an Encapsulated PostScript (EPS) file, our RaspCade cabinet is optimised for online laser cutting services, so getting your own cabinet is as simple as downloading our design (**magpi.cc/21jHT61**) and then uploading it to your chosen service. Jason Barnett (**@boeeerb**) at Cyntech kindly helped with our first prototype, and we used Just Add Sharks (**justaddsharks.co.uk**) for our final cut, which cost us around £15 including delivery.

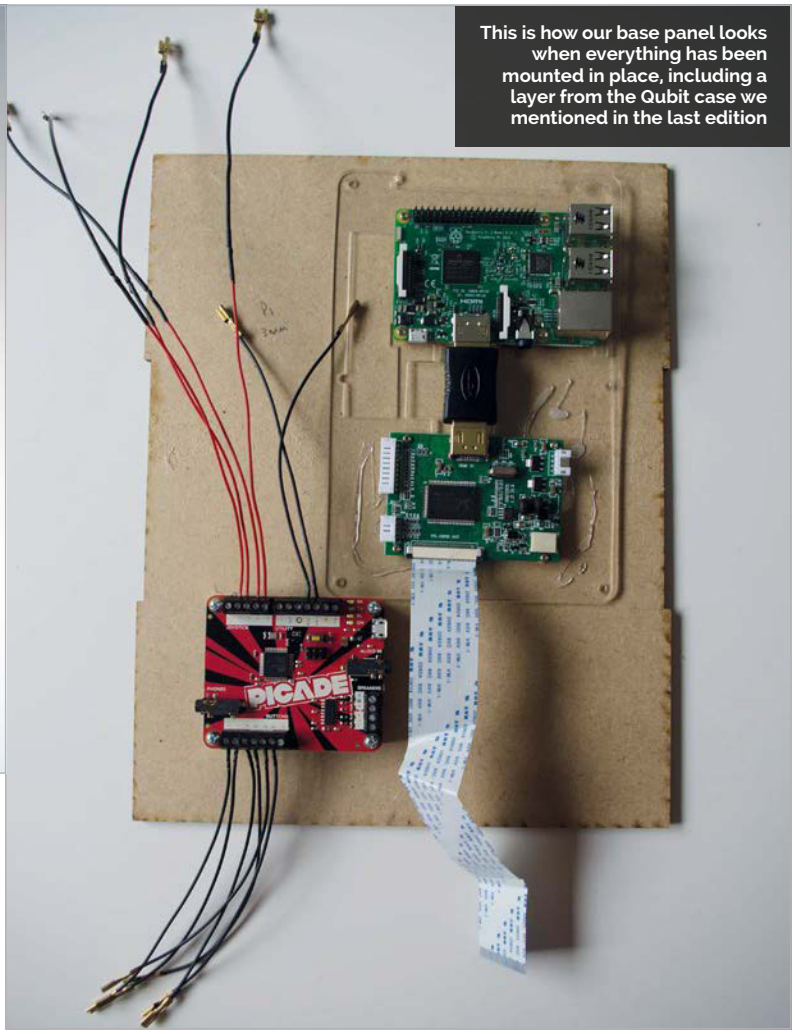
>STEP-02

Some drilling necessary

To allow for some wiggle room when assembling the RaspCade, you may have to drill your own mounting holes to suit. As we used the Qubit case for the screen, we glued a layer from this to our base, as



The speakers are attached to the sides of the case



This is how our base panel looks when everything has been mounted in place, including a layer from the Qubit case we mentioned in the last edition

it meant we could mount the LCD driver board and Pi very easily, but it's equally easy to add your own mounting holes and standoffs. In our build, we used a small drill bit to add several mounting points on the base unit, so that we could install standoffs for the Picade PCB, as well as holes for the two speakers.

>STEP-03

Mounting the speakers

It's very easy to mount the speakers, as the ones we used come with four holes that are ideally suited to M4 bolts. After placing our speaker in the correct position first, we marked the positions for our holes with a pencil, drilled the holes, and then used the countersink bit to countersink the hole so that the bolt would sit flush with the cabinet when assembled. It was then very simple to solder the positive and negative wires to each speaker, ready to connect to the Picade PCB. It's useful to put some coloured electrical tape around the positive wires, so you can find them quickly later.

>STEP-04

Assembling the cabinet

Our RaspCade design includes simple box joints, so assembling the cabinet is pretty straightforward. We recommend doing a test run before gluing together, just so you are confident you get each panel the right way round! Using a strong wood glue, start by gluing one of the side panels to the base unit and then let that dry. We propped ours against a wall whilst the glue dried (which can take 24 hours) to ensure it was held in the correct position. We then added the other side panel, repeating the same process.

>STEP-05

Let the glue dry!

The hardest part for us was waiting for the glue to dry properly before starting the next panel! However, it's worth waiting to be sure that the glue has dried properly, otherwise it could ruin your build. When we added the top panel, we tied string around the sides and placed a small weight on top (a tin of beans would do!), to hold the panel together whilst the glue dried. This meant that we had a perfectly square cabinet frame once everything had dried, and now we could add some internal parts, including our Raspberry Pi!

BE PATIENT WHEN GLUING!

Think where you will put your RaspCade when the glue is drying and don't mess with it for at least 24 hours!

>STEP-06

Connect your wires

Before gluing all the panels together, we found it easier to put our electronics in place first. We connected our buttons, joystick, and speaker wires to the Picade PCB and then screwed the Picade PCB onto the standoffs so it was secured inside. We then glued the front panel in place, then the joystick panel, and then the screen, ensuring we waited for the glue to dry each time. Lastly, we added two small jewellery box hinges to the back panel and a magnetic catch, so we could get to the insides of our RaspCade quickly and easily if needed!

DON'T OVERTIGHTEN SCREWS

Our cabinet is made from MDF, so don't overtighten any screws, otherwise you could damage the wood.

FREQUENTLY ASKED QUESTIONS

Your technical hardware and software problems solved...

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Email **magpi@raspberrypi.org** or find us on **raspberrypi.org/forums** to feature in a future issue.

BUYING A RASPBERRY PI

WHERE CAN I BUY A RASPBERRY PI?

Online

Most versions of the Raspberry Pi are available online, from many electronics and big online stores. You can buy them on Amazon, hobbyist stores like Pimoroni, or go to electronics providers such as Element14 and RS Components.

In store

Some big electronics stores sell Raspberry Pi hardware in-store. In the UK, this includes Maplin; in the USA, places like Micro Center are your best bet. You can also get them at most Raspberry Jams with merch tables.

What does the Raspberry Pi come with?

It depends where you buy it from, but it will either be the core board with no accessories, or you could get a case bundle or even a full kit bundle to get you started. They all vary in cost, of course.

Below The brand new official starter kit comes with everything needed

WHERE CAN I BUY A PI ZERO?

Online

The Raspberry Pi Zero is stocked in a few places online, such as Pimoroni and The Pi Hut in the UK, and Adafruit in the US. Canakit in Canada has recently begun selling them as well. Check stock on **whereismypizero.com** when you want to buy one.

In store

So far, Micro Centers in the US are the only places you can buy the Pi Zero in person. This may change in the future now that supply is keeping up with demand, but for now you'll have to find your local Micro Center to get one: **magpi.cc/2cies2o**.

Subscribe to The MagPi

If you buy a six- or twelve-month print subscription to *The MagPi*, you will receive a Pi Zero v1.3 (the one with a camera port) for free, along with a bundle of cables to use it. Read more about the offer on page 66.

WHERE CAN I BUY ACCESSORIES?

Raspberry Pi add-ons

Official HATs, cameras, and other add-ons for the Raspberry Pi can be purchased from any good Raspberry Pi hobby website, such as Pimoroni, The Pi Hut, or Adafruit. You can also get them from official Pi distributors Element14 and RS Components.

Electronics components

While components and bits you need for electronics are available at Pi hobby sites, you can also get them from any electronics supplier or store that specialises in them. Breadboards and components that work with the GPIO pins are standard parts.

Input devices

The Raspberry Pi will work with any standard USB mouse and keyboard combo, along with most wireless versions that use a dongle or a Bluetooth connection. If you have a computer at home, you can always borrow the parts from there!

FROM THE RASPBERRY PI FAQ
RASPBERRYPI.ORG/HELP

What is the user name and password for the Raspberry Pi?
The default user name for the standard Raspbian operating system is **pi**, and the default password is **raspberry**. If this doesn't work, check the information about your specific distro on the downloads page: **raspberrypi.org/downloads**.

Why does nothing happen when I type in my password? Did my Raspberry Pi freeze?
To protect your information, Linux doesn't display anything when typing in passwords in the Bash prompt or the terminal. As long as you were able to see the user name being typed in, your keyboard is working correctly.

What are the differences between models?
These are the current models of the Raspberry Pi available: the Pi 2 Model B, the Pi 3 Model B, the Pi Zero, and the Pi 1 Model B+ and A+.

The Model A+ is a low-cost variant of the Raspberry Pi. It has one USB port, 40 GPIO pins, and no Ethernet port. The original version came with 256MB of RAM, but the new model (launched in August 2016) has 512MB. The Model B+ is the final revision of the original Raspberry Pi. It has 512MB RAM, four USB ports, 40 GPIO pins, and an Ethernet port. In February 2015, it was superseded by the Pi 2 Model B, the second generation of the Raspberry Pi. The Pi 2 shares many specs with the Pi 1 B+, but uses a 900MHz quad-core ARM Cortex-A7 CPU and has 1GB RAM. The Pi 2 is completely compatible with first-generation boards. The Pi 3 Model B was launched in February 2016; it uses a 1.2GHz 64-bit quad-core ARM Cortex-A53 CPU, has 1GB RAM, plus integrated 802.11n wireless LAN and Bluetooth 4.1. Finally, the Pi Zero is half the size of a Model A+, with a 1GHz single-core CPU and 512MB RAM, plus mini-HDMI and micro-USB ports (requiring adapters).

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Available on the App Store

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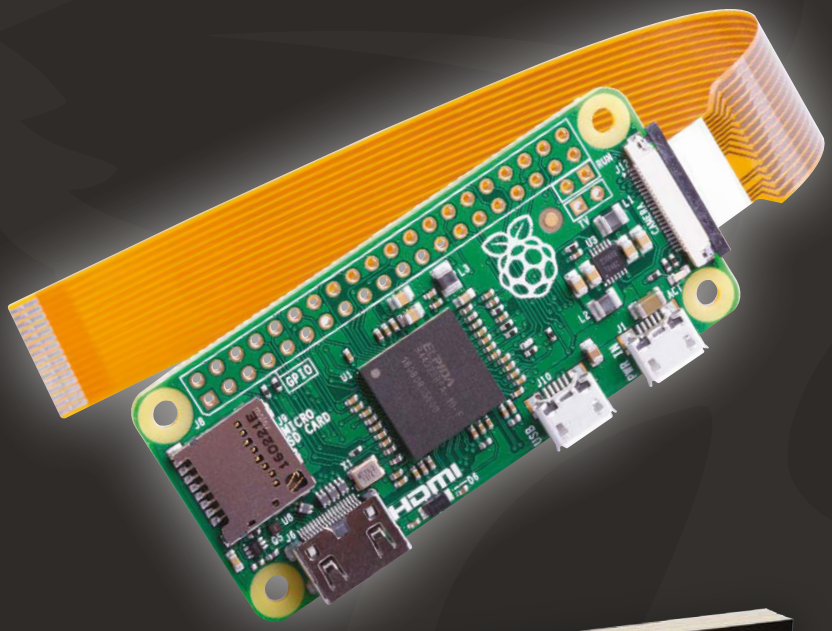

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Mag#50

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HOW TO BOOT YOUR RASPBERRY PI WITH USB OR ETHERNET

Discover two new ways to start up your Raspberry Pi

The trusty SD card has served us well, bless it. But now there are two new options: USB and Ethernet.

Booting from the SD card isn't going away, so you can still use it. But it's worth experimenting with these new features, as they're both very interesting.

We caught up with Gordon Hollingworth, Raspberry Pi's director of engineering. He helped explain what's going on.

"Inside the processor chip there's a little bit of ROM (read-only memory) which contains some software to begin the boot process," explains Gordon. The boot process is what happens when you power up a Raspberry Pi; it's the instructions hardwired into the computer to look for attached disks and start loading an operating system.

"In the past, the main boot mode supported was by SD card," says Gordon. "So when the Raspberry Pi was powered up, it looked for an SD card and looked for a special file (called bootcode.bin) on the FAT partition of the card.

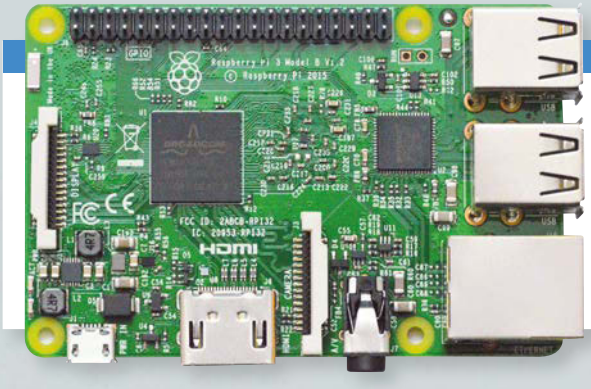
"I've added a few more boot modes," he tells us. "The first is a mass storage device (MSD) that allows it [the Raspberry Pi] to search for bootcode.bin on an attached USB drive."

As well as being easier to source, USB flash drives are slightly cheaper than microSD cards, especially at higher capacity.

"The second [mode] to implement was DHCP/TFTP boot. This allows the Pi to be booted over a network," continues Gordon.

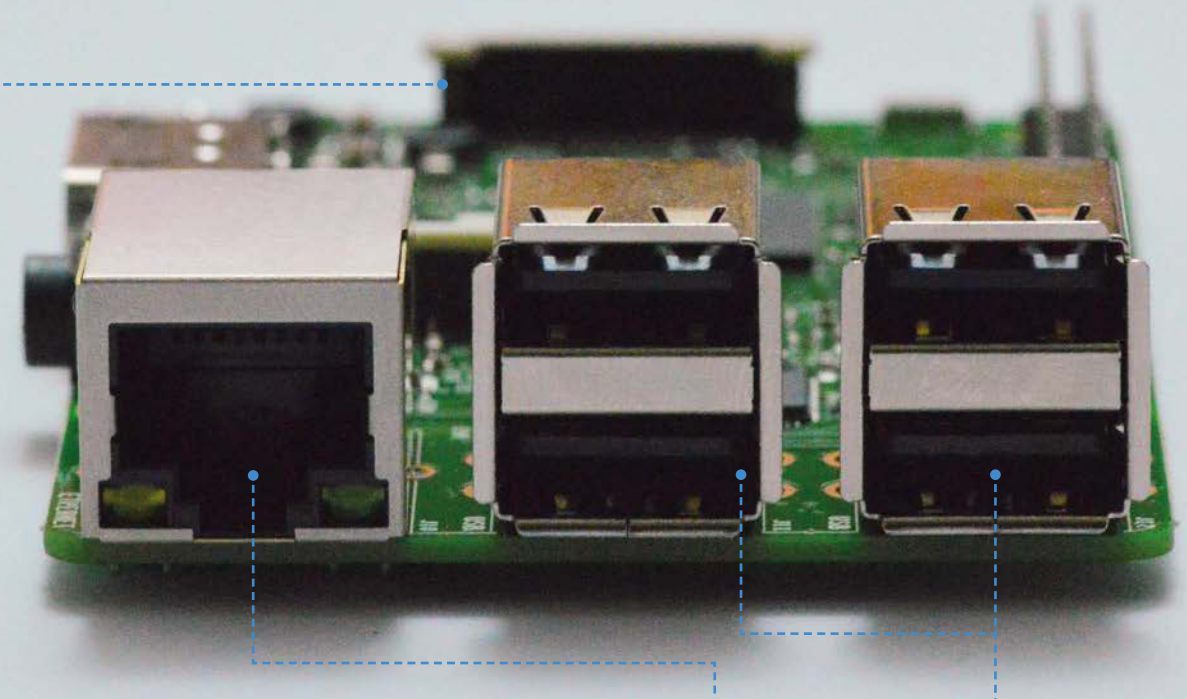
"I began writing the changes to the boot ROM code around twelve months ago, but in total the work required took around three to four months," he reveals. "The main difficulty is having to implement a complete USB host, including being able to enumerate hubs and talk to all the devices in the USB network. It also needed to implement the USB SCSI protocol and the Ethernet setup, as well as all the network layer for UDP, DHCP, TFTP, and ARP protocols. All of that had to be implemented in 32kB."

We think Gordon's done a sterling job of fitting not one, but three different boot processes in the small space allocated to the boot ROM. So let's take advantage of that effort and discover how to boot from USB and Ethernet.



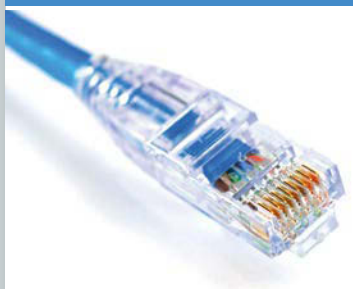
RASPBERRY PI 3

You'll need a Raspberry Pi 3 to take advantage of the new boot modes. The boot code update is stored in the BCM2837 (the system on a chip) and isn't included with other models of Raspberry Pi.



SD CARD BOOT

A microSD card is currently used to boot a Raspberry Pi. You can still boot the Raspberry Pi from the SD card, but now you have two more options available.



ETHERNET BOOT

An Ethernet cable is used to connect your Raspberry Pi to a network. Now it can load the operating system image directly from the network.

USB BOOT

The operating system can be loaded onto the USB flash drive and used to start up the Raspberry Pi. You'll need an SD card to set up the drive (for now), but it then allows for SD card-free booting.

BOOTING FROM USB

Turn a USB flash drive into a boot drive and start up your Raspberry Pi

You'll Need

- Raspberry Pi 3
- USB drive
- microSD card

In this tutorial we're going to look at booting a Raspberry Pi 3 using a USB flash drive.

You can use any MSD (mass storage device) to boot the Raspberry Pi, which includes USB flash drives and hard drives.

You will, however, need a microSD card to set up the Raspberry Pi in the first instance. Start by flashing a microSD card with Raspbian.

If you're running Raspbian Lite, you will need to run an rpi-update:

```
sudo apt-get update; sudo apt-get install rpi-update
```

Now you need to switch the update branch from the default (master) to next:

```
sudo BRANCH=next rpi-update
```

Then we need to enable USB boot mode by adjusting the config.txt file:

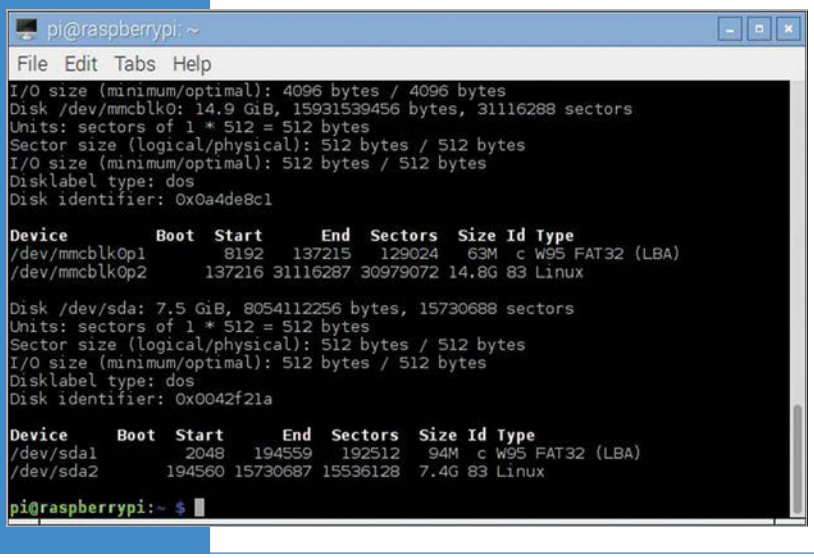
```
echo program_usb_boot_mode=1 | sudo tee -a /boot/config.txt
```

This adds 'program_usb_boot_mode=1' to the end of **/boot/config.txt** (you can check it with **`cat /boot/config.txt`**). Reboot the Pi with **`sudo reboot`**, then check that the OTP has been programmed with:

```
vcgencmd otp_dump | grep 17:
17:3020000a
```

Ensure the output 0x3020000a is correct.

Below Here we have a Raspberry Pi running just an attached USB drive mounted on /dev/sda


pi@raspberrypi: ~
File Edit Tabs Help
I/O size (minimum/optimal): 4096 bytes / 4096 bytes
Disk /dev/mmcblk0: 14.9 GiB, 15931539456 bytes, 31116288 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x0a4de8c1
Device Boot Start End Sectors Size Id Type
/dev/mmcblk0p1 8192 137215 129024 63M c W95 FAT32 (LBA)
/dev/mmcblk0p2 137216 31116287 30979072 14.8G 83 Linux
Disk /dev/sda: 7.5 GiB, 8054112256 bytes, 15730688 sectors
Units: sectors of 1 * 512 = 512 bytes
Sector size (logical/physical): 512 bytes / 512 bytes
I/O size (minimum/optimal): 512 bytes / 512 bytes
Disklabel type: dos
Disk identifier: 0x0042f21a
Device Boot Start End Sectors Size Id Type
/dev/sda1 2048 194559 192512 94M c W95 FAT32 (LBA)
/dev/sda2 194560 15730687 15536128 7.4G 83 Linux
pi@raspberrypi:~ $

Prepare the USB storage device

Attach a USB storage device (which will be completely erased) to the Raspberry Pi.

Rather than downloading the Raspbian image again, we will copy it from the SD card still in the Raspberry Pi. The source device (SD card) will be **/dev/mmcblk0** and the destination device (USB disk) should be **/dev/sda**, assuming you have no other USB devices connected.

```
sudo umount /dev/sda
```

Note the command 'umount', not 'unmount'. Next, you need to open Parted, pointing to the drive:

```
sudo parted /dev/sda
```

You'll see a 'Welcome to GNU Parted!' message. You'll also see **`(parted)`** instead of the **`$`** symbol on the command line, indicating that you're in Parted. Enter:

```
mktable msdos
```

You'll see: 'Warning: The existing disk label on /dev/sda will be destroyed and all data on this disk will be lost. Do you want to continue?' Enter 'yes'.

Now create the two partitions: a FAT32 taking up 100MB of space, the second ext4 taking up the rest.

```
mkpart primary fat32 0% 100M
mkpart primary ext4 100M 100%
```

Use **`print`** to view the details of the partitions.

Ours says:

Model: UFD 2.0 Silicon-Power8G (scsi)
Disk /dev/sda: 8054MB
Sector size (logical/physical): 512B/512B
Partition Table: msdos
Disk Flags:

Number	1	2
Start	1049kB	99.6MB
End	99.6MB	8054MB
Size	98.6MB	7954MB
Type	primary	primary
File system	fat32	ext4
Flags	lba	lba

Your Parted print output should look similar to the one above. Create the boot and root file systems:

```
sudo mkfs.vfat -n BOOT -F 32 /dev/sda1
sudo mkfs.ext4 /dev/sda2
```

Our disk is formatted. It's time to mount the target file systems on sda1 and sda2:

```
sudo mkdir /mnt/target
sudo mount /dev/sda2 /mnt/target/
sudo mkdir /mnt/target/boot
sudo mount /dev/sda1 /mnt/target/boot/
```

Now we need to copy the running Raspbian system to the target. We're going to download a program called rsync and use it to copy Raspbian across.

```
sudo apt-get update; sudo apt-get install rsync
sudo rsync -ax --progress / /boot /mnt/target
```

The files will be displayed on the screen as they are copied across. The copy process may take some time.

Now regenerate your SSH host keys:

```
cd /mnt/target
sudo mount --bind /dev dev
sudo mount --bind /sys sys
sudo mount --bind /proc proc
sudo chroot /mnt/target
rm /etc/ssh/ssh_host*
dpkg-reconfigure openssh-server
exit
sudo umount dev
sudo umount sys
sudo umount proc
```

Edit **/boot/cmdline.txt** so that it uses the USB storage device as the root file system instead of the SD card:

```
sudo sed -i "s,root=/dev/mmcblk0p2,root=/
dev/sda2," /mnt/target/boot/cmdline.txt
```

The same needs to be done for fstab:

```
sudo sed -i "s,/dev/mmcblk0p,/dev/sda," /
mnt/target/etc/fstab
```

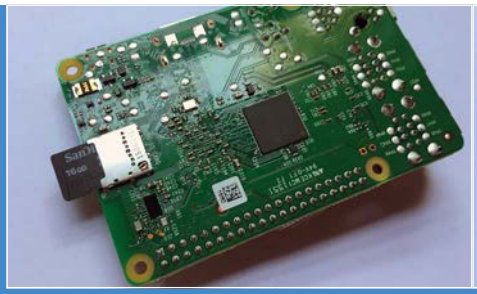
Finally, unmount the target file systems, and power off the Pi:

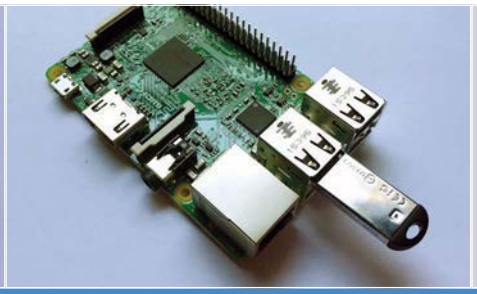
```
cd ~
sudo umount /mnt/target/boot
sudo umount /mnt/target
sudo poweroff
```

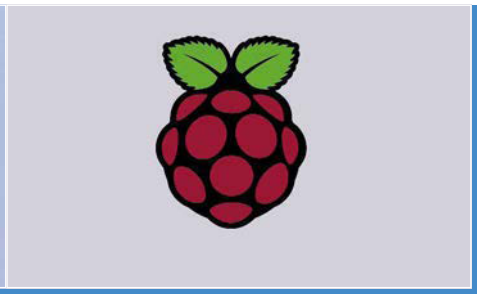
Disconnect the power supply from the Pi, remove the SD card, and reconnect the power supply.

If all has gone well, the Raspberry Pi will begin to boot after a few seconds.

USB BOOT OVERVIEW







>STEP-01 - SWITCH TO NEXT

First, you need to install Raspbian using an SD card and open it on a Raspberry Pi 3. Switch updates from the master branch to the next branch. This enables you to run the beta features, including the new boot modes.

>STEP-02 - COPY RASPBIAN

Next, you attach a USB flash drive and use Parted to format it and create two partitions: FAT32 for booting and ext4 for Raspbian. Then use rsync to duplicate the entire Raspbian image on the SD card to the flash drive.

>STEP-03 - UPDATE SSH

Finally, you need to regenerate the SSH keys on your USB flash drive by deleting the old files and reconfiguring openssh-server. OpenSSH is used to secure Linux, and this will enable the new flash drive to run. Now when you reboot the Raspberry Pi, you can boot directly from the USB flash drive.

ETHERNET BOOT

Discover how to boot a Raspberry Pi device (or several boards) over a network using network boot

You'll Need

- Two Raspberry Pi boards (one a Raspberry Pi 3)
- Ethernet cable
- 16GB (or larger) microSD card

The third available boot mode for the Raspberry Pi 3 is network boot. With this feature enabled, you can install Raspberry Pi on one computer and then use it to boot another Raspberry Pi on the same network.

In particular, you need two boards. One acts as the server (booted using a microSD card containing Raspbian); the other is the client which will boot into Raspbian without any attached storage device.

Only one of the Raspberry Pi devices (the server) requires a microSD card, although it has to be at least 16GB capacity. This is because it must carry the image of Raspbian used to boot the board, and another image of Raspbian used to boot the computers on the network.

"The big advantage with network booting," says Gordon Hollingworth, Raspberry Pi's director of engineering, "is with a small penalty for booting time, you can boot a whole classroom of Raspberry Pi boards from a single server, with absolutely no programming of SD cards."

"We use the network booting with our test subsystem," explains Gordon. "This allows us to completely reboot a Pi with no reliance on old boot software". So if they break something during testing, they can just reload the operating system.

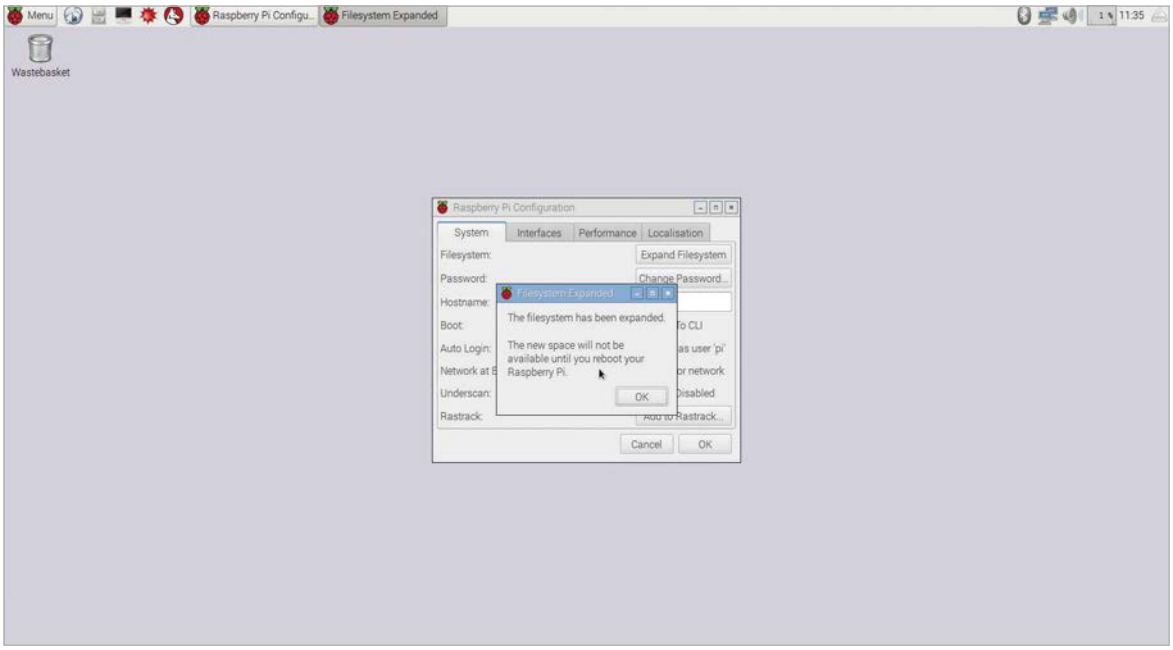
"Since you can easily create a shared filing system," he continues, "it makes it very easy to add Raspberry Pis to a server to provide a whole network of Raspberry Pis, with no fiddly SD cards."

Network boot your Raspberry Pi

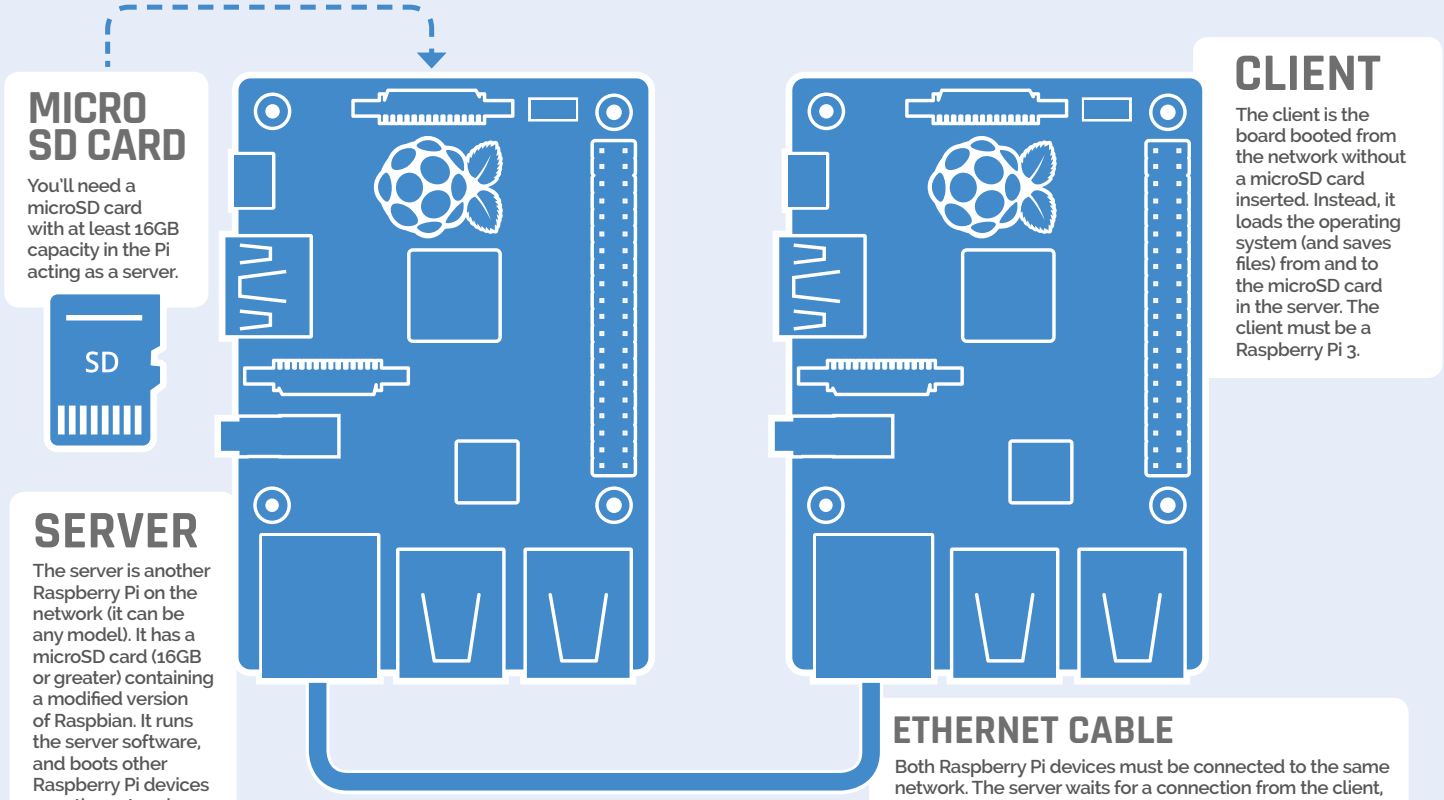
This tutorial explains how to set up a simple DHCP / TFTP server which will allow you to boot a Raspberry Pi 3 from the network.

This assumes you have an existing home network and want to use a Raspberry Pi for the server.

Install Raspbian Lite (or the full OS if you want) from the Downloads page onto an SD card, using Win32DiskImager if you're on Windows, or dd if you're on Linux/Mac.



Right Don't forget to expand the file system so you have enough space for a cloned copy of Raspbian (used by the client)


MICRO SD CARD
You'll need a microSD card with at least 16GB capacity in the Pi acting as a server.
SD
SERVER
The server is another Raspberry Pi on the network (it can be any model). It has a microSD card (16GB or greater) containing a modified version of Raspbian. It runs the server software, and boots other Raspberry Pi devices over the network.
CLIENT
The client is the board booted from the network without a microSD card inserted. Instead, it loads the operating system (and saves files) from and to the microSD card in the server. The client must be a Raspberry Pi 3.
ETHERNET CABLE
Both Raspberry Pi devices must be connected to the same network. The server waits for a connection from the client, and then loads the operating system over the network.

Place the microSD card into the client Raspberry Pi (the Raspberry Pi 3 that you intend to boot over the network and without the card in future).

Just as with USB boot, you'll first need to prepare the **/boot** directory with experimental boot files.

If you're using Raspbian Lite, you need to run an rpi-update before you can use it:

```
sudo apt-get update; sudo apt-get install rpi-update
sudo BRANCH=next rpi-update
```

Then enable USB boot mode with:

```
echo program_usb_boot_mode=1 | sudo tee -a /boot/config.txt
```

This adds 'program_usb_boot_mode=1' to the end of **/boot/config.txt**. Reboot the Raspberry Pi:

```
sudo reboot
```

Once the client Pi has rebooted, check that the OTP (one-time programmable) memory has been programmed using:

```
vcgencmd otp_dump | grep 17:
17:3020000a
```

Ensure the output is '3020000a'.

The client configuration is almost done. The final thing to do is to remove the 'program_usb_boot_mode' line from **config.txt**:

```
sudo nano /boot/config.txt
```

Scroll down to the end and remove the line marked 'program_usb_boot_mode=1'. Press **CTRL+O** and hit **RETURN** to save the file, then **CTRL+X** to return to the command line.

Finally, shut down the client Pi with **`sudo poweroff`**.

Server configuration

Remove the microSD card and transfer it to the server Raspberry Pi. Power it up and immediately expand the root file system to take up the entire SD card. Open **Menu > Preferences > Raspberry Pi Configuration** and click **Expand Filesystem**. Click **OK > Yes** to reboot the Pi. Alternatively, use **`sudo raspi-config`**.

The client Raspberry Pi needs a root file system to boot from, which has to be separate from the file system being used by the server. So before we do anything else on the server, we're going to make a full copy of its file system and put it into a directory called **/nfs/client1**.

```
sudo mkdir -p /nfs/client1
sudo apt-get install rsync
sudo rsync -xa --progress --exclude /nfs /
/nfs/client1
```

Regenerate the SSH host keys on the client file system by chrooting into it:

```
cd /nfs/client1
sudo mount --bind /dev dev
sudo mount --bind /sys sys
sudo mount --bind /proc proc
sudo chroot .
rm /etc/ssh/ssh_host_*
dpkg-reconfigure openssh-server
exit
sudo umount dev
sudo umount sys
sudo umount proc
```

Now you need to find the settings of your local network. First, locate the address of your router (or gateway), which you can find with:

```
ip route | grep default | awk '{print $3}'
```

This will be a four-digit number, and typically it ends in 1. Ours is 192.168.0.1.

Next, we need to find the IP address of our server Raspberry Pi on the network. This will be the same address, but with a different last number.

```
ip -4 addr show dev eth0 | grep inet
```

This should give an output like:

```
inet 192.168.0.197/24 brd 192.168.0.255
scope global eth0
```

The first address (inet) is the IP address of your server Pi on the network. Ours is device 197. The second part (the brd) is the network size (the number of total devices allowed on the network, which is almost always 255).

The part after the slash is the network size. It's highly likely that yours will be a /24. Write down both the inet and brd numbers.

Finally, note down the address of your DNS server, which is the same address as your gateway. You can find this with:

```
cat /etc/resolv.conf
```

You will see 'nameserver' followed by another number. You may have more than one nameserver address. We get:

```
nameserver 194.168.4.100
nameserver 194.168.8.100
```

Write down the nameserver address(es).

Configuring the server

Now we're going to configure a static network address on your server Raspberry Pi using **sudo nano /etc/network/interfaces**. Change the line 'iface eth0 inet manual' so that the address is the inet you wrote down, the netmask address is 255.255.255.0, and the gateway address is the number received using **ip route**. Ours looks like this:

```
auto eth0
iface eth0 inet static
        address 192.168.0.197
        netmask 255.255.255.0
    gateway 192.168.0.1
```

Use **CTRL+O**, **RETURN**, and **CTRL+X** to save the text file and return to the command line.

Next, we disable the DHCP client daemon and switch to standard Debian networking:

```
sudo systemctl disable dhcpcd
sudo systemctl enable networking
```

Reboot for the changes to take effect:

```
sudo reboot
```

At this point, you won't have working DNS, so you'll need to add the server you noted down before to **/etc/resolv.conf**. Do this by using the following command, where the IP address is that of the router/gateway address you found earlier:

```
echo "nameserver 192.168.0.1" | sudo tee -a
/etc/resolv.conf
```

Then make the file immutable (because otherwise dnsmasq will interfere) with the following command:

```
sudo chattr +i /etc/resolv.conf
```

Next, we're going to install some software we need:

```
sudo apt-get update
sudo apt-get install dnsmasq tcpdump
```

Stop dnsmasq breaking DNS resolving:

```
sudo rm /etc/resolvconf/update.d/dnsmasq
sudo reboot
```

Now start tcpdump so you can search for DHCP packets from the client Raspberry Pi:

```
sudo tcpdump -i eth0 port bootpc
```

Connect the client Raspberry Pi to your network

and power it on. Check that the LEDs illuminate on the client after around 10 seconds, then you should get a packet from the client, 'BOOTP/DHCP, Request from …'

It will have lines that look like:

```
IP 0.0.0.0.bootpc > 255.255.255.255.bootps:
BOOTP/DHCP, Request from b8:27:eb...
```

Now we need to modify the dnsmasq configuration to enable DHCP to reply to the device. Press **CTRL+C** on the keyboard to exit the tcpdump program, then type the following:

```
sudo echo | sudo tee /etc/dnsmasq.conf
sudo nano /etc/dnsmasq.conf
```

Replace the contents of **dnsmasq.conf** with:

```
port=0
dhcp-range=192.168.0.255,proxy
log-dhcp
enable-tftp
tftp-root=/tftpboot
pxe-service=0,"Raspberry Pi Boot"
```

Make sure the first address of the dhcp-range line is the broadcast address (brd) number you noted down earlier (the number typically ending in 255).

Now create a **/tftpboot** directory:

```
sudo mkdir /tftpboot
sudo chmod 777 /tftpboot
sudo systemctl enable dnsmasq.service
sudo systemctl restart dnsmasq.service
```

Now monitor the dnsmasq log:

```
tail -f /var/log/daemon.log
```

You should see several lines like this:

```
raspberrypi dnsmasq-tftp[1903]: file
/tftpboot/bootcode.bin not found
```

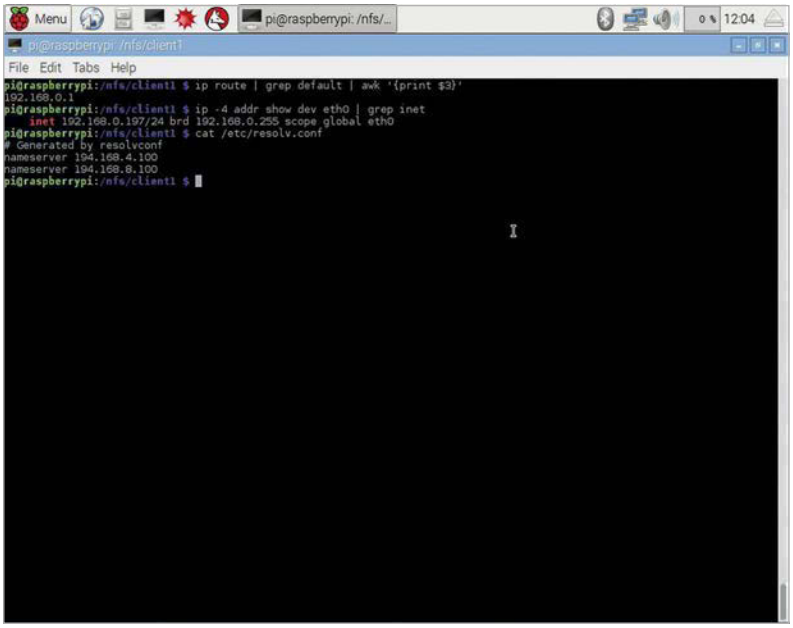
Next, you'll need to copy **bootcode.bin** and **start.elf** into the **/tftpboot** directory; you should be able to do this by just copying the files from **/boot**, since they are the right ones. We need a kernel, so we might as well copy the entire boot directory.

First, use **CTRL+Z** to exit the monitoring state. Then type the following:

```
cp -r /boot/* /tftpboot
```

Restart dnsmasq for good measure:

```
sudo systemctl restart dnsmasq
```


Menu
pi@raspberrypi: /nfs/...
12:04
File Edit Tabs Help
pi@raspberrypi:/nfs/client1 $ ip route | grep default | awk '{print $3}'
192.168.0.1
pi@raspberrypi:/nfs/client1 $ ip -4 addr show dev eth0 | grep inet
inet 192.168.0.197/24 brd 192.168.0.255 scope global eth0
pi@raspberrypi:/nfs/client1 $ cat /etc/resolv.conf
Generated by resolvconf
nameserver 194.168.4.100
nameserver 194.168.8.100
pi@raspberrypi:/nfs/client1 $

Above Note network settings when you set up the client. These need to be added to the server so it can locate your client Pi on the network

Set up root

We now have a Raspberry Pi that boots until it tries to load a root file system (which it doesn't have). All we have to do to get this working is to export the **/nfs/client1** file system we created earlier:

```
sudo apt-get install nfs-kernel-server
echo "/nfs/client1 *(rw,sync,no_subtree_
check,no_root_squash)" | sudo tee -a /etc/
exports
sudo systemctl enable rpcbind
sudo systemctl restart rpcbind
sudo systemctl enable nfs-kernel-server
sudo systemctl restart nfs-kernel-server
```

We need to edit the **cmdline.txt** file:

```
sudo nano /tftpboot/cmdline.txt
```

From 'root=' onwards, replace it with:

```
root=/dev/nfs nfsroot=192.168.0.197:/
nfs/client1 rw ip=dhcp rootwait
elevator=deadline
```

You should substitute the IP address here with the inet address you noted down earlier (found using **`ip -4 addr show dev eth0 | grep inet`**).

Finally, enter:

```
sudo nano /nfs/client1/etc/fstab
```

Remove the '/dev/mmcblkp1' and 'p2' lines (only 'proc' should be left).

Good luck! If it doesn't boot first time, keep trying. It can take a minute or so for the Raspberry Pi to boot, so be patient.

Maker Says

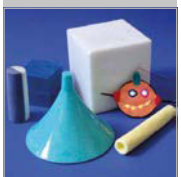
"Stick it. Shape it. It turns into rubber"
Sugru

SUGRU REBEL TECH KIT

Billed as 'mouldable glue,' is Sugru's new Rebel Tech Kit the ultimate introduction for makers and tinkerers?

Related

OOGOO
Created by mixing silicone caulk with corn starch, Oogoo is a DIY alternative to Sugru which can be made in volume for very little money.



Varies
magpi.cc/2cCL9fg

Sugru has long struggled to make an impact outside of maker circles. Its original incarnation was billed as 'soft-touch silicone rubber that moulds and sets permanently', a somewhat wordy but accurate summary of its capabilities. Nowadays, that has been condensed to 'mouldable glue', which still somehow fails to quickly capture the attention and get across just how useful Sugru can be in a variety of situations.

That's where, its creators hope, the Rebel Tech Kit comes in. Created following the success of the Home Hacks Made Easy kit, the Rebel Tech Kit is designed to appeal to those who prefer their gadgets and gizmos, rather than anyone looking to fix a leaky tap or make a sieve more comfortable to use.

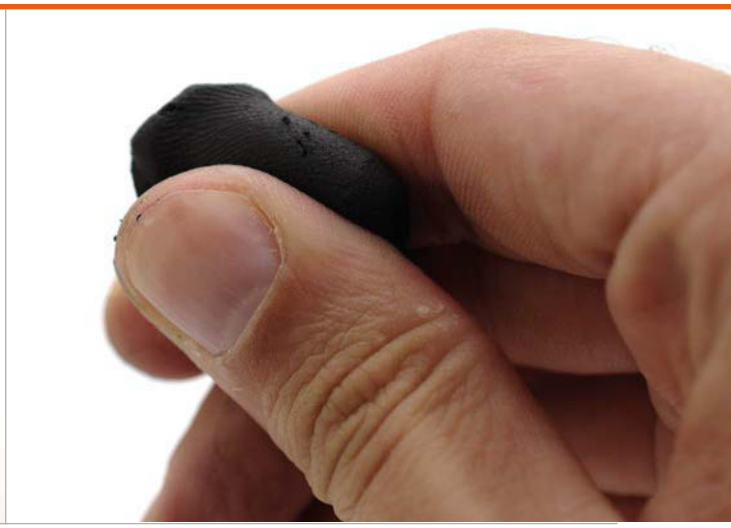
Inside, the kit follows the existing formula: four individual sachets of Sugru – in white, black, grey, and red – are housed in a neat little reusable tin, as is a small plectrum which can aid in the moulding and shaping process.

It's the bundled booklet, though, that's the real star of the show. Printed in full colour, the guide book runs through 14 individual projects to help showcase the capabilities of Sugru. There's nothing particularly groundbreaking – the most advanced of the listed projects involves 3D printing a mould which can be used to shape Sugru cable strain-relief grommets – but each is clearly detailed, though perhaps a bit briefly given the limit of two pages per project.

Flicking through the booklet gives an insight into the various ways in which Sugru can enhance your existing technology. Showcased 'fixes', as the Sugru community terms them, include hanging media playback boxes on the back of TVs, customising console gamepads, creating a hook on which to hang your headphones, and even adding multicoloured bumpers to an old digital camera to make it suitable

sugru.com

£10 / $15



Above The handy guide shows you the many different ways you can use Sugru

for kids' use; though the latter, sadly, requires far more Sugru than is provided in the kit.

The bundled sachets of Sugru are used like any other: wash your hands; cut open the foil sachet and remove the Sugru, which has a texture slightly softer than Blu-Tack; knead the Sugru between your fingers, mixing multiple packets together if you want a different colour or a higher volume of Sugru; press the Sugru against the surface to be covered, or between two surfaces if you're taking the 'mouldable glue' tag line to heart; and finish by smoothing the Sugru using tools or your fingers, both wetted with soapy water. After around a day, the Blu-Tack texture has given way to a firm yet flexible rubber texture, with strong adhesion to the surface on which it dried.

It's here that the first issue becomes apparent: Sugru is quite difficult to remove from your fingers, and the dyes used can stain. If you follow the bundled instructions properly and rub your hands down with a paper towel before applying soap and water, you'll find it easier, but it can still take considerable scrubbing before you're properly clean.

There's a value concern to raise, too. At £10/$15, the kit costs nearly as much as an eight-pack of Sugru (£12.99/$22) while providing less than half the raw material. Yes, the booklet is of a particularly high quality and the tin is nice too, but the Sugru website and regular newsletter both include far more project ideas than the booklet, while the tin's usefulness is limited by the advice to keep unused sachets of Sugru in the fridge to extend their shelf life. Those who do wish to carry sachets of Sugru in their bag or pocket using the tin are, of course, free to do so, but can expect to be replacing unused but 'stale' sachets as a result.

The Rebel Tech Kit's true focus lies in two areas: as a gift, and as an introduction. As a gift it's a great bundle: the inclusion of the tin, regardless of its questionable utility, raises what would otherwise be a fairly utilitarian collection of 'mouldable glue' into something worthy of a stocking filler. As an introduction to Sugru, the booklet fires up the imagination without the need to launch a web browser, though the four Sugru packs included will likely be quickly used up in the initial burst of enthusiasm.

Last word

The Sugru Rebel Tech Kit is a fantastic idea, and the booklet makes a great introduction to its use. Better value can be found, however, in buying a standard multipack and browsing projects on the website.

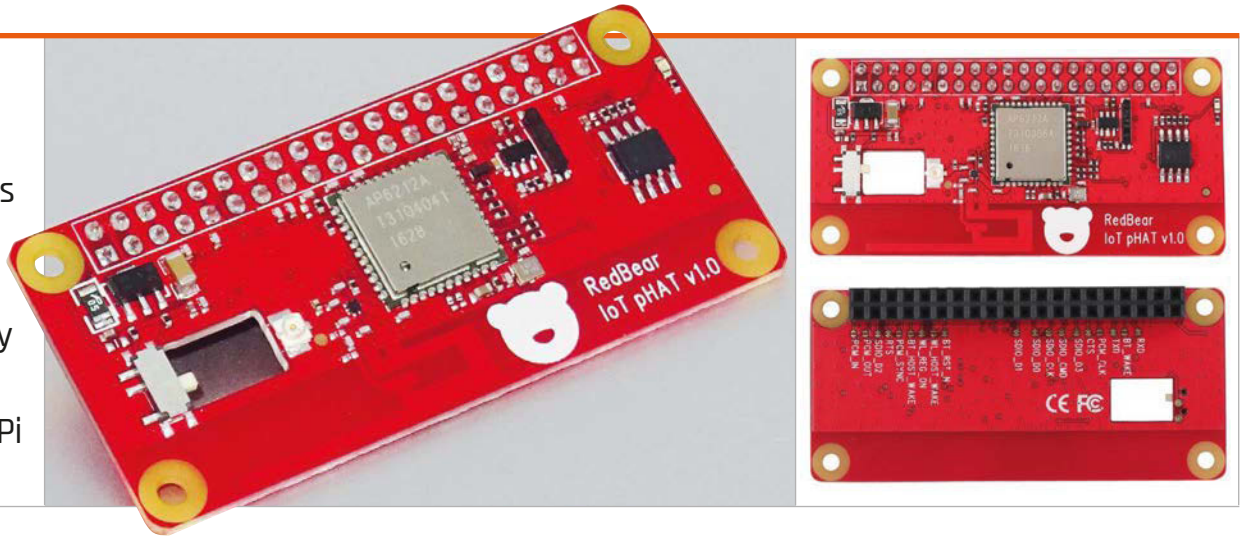
magpi.cc/2cl06BV

£10 / $13

Maker Says

"Provides WiFi and Bluetooth connectivity for the Raspberry Pi"

Red Bear



IOT PHAT

An easy way to add WiFi and Bluetooth to your Pi Zero

One of the best new features of the Raspberry Pi 3 is its built-in wireless LAN and Bluetooth. Wouldn't it be great to have the same convenience on a Pi Zero (and other Pi models)? That's the thinking behind Red Bear's IoT pHAT. When mounted on the GPIO pins, this Zero-size board provides WiFi (802.11bgn / 2.4GHz) and Bluetooth (4.1 and BLE) connectivity. So you don't need to use a dongle plugged into the Pi Zero's solitary data micro-USB port via a USB OTG adapter.

The IoT pHAT is pretty much plug-and-play, coming pre-soldered with a 40-pin female header. Upon booting up, the Linux kernel reads the configuration from the on-board EEPROM and turns on the WiFi driver. You can then connect to your wireless router as usual, via the desktop panel icon or command line.

While on our early model we needed to update the pHAT's firmware via several terminal commands to get more stable WiFi and functional Bluetooth, any new boards shipped should already have this pre-installed and so work perfectly from the start. One caveat is that, at the time of writing, you'll still need to add a line to the `/boot/config.txt` file to set the UART clock to 48MHz to activate Bluetooth, but this is due to be added to the next official Raspbian image. Once Bluetooth is working, you can pair devices – such as a keyboard, mouse, and gamepad – via the desktop panel icon or command line, as usual.

In our tests, the IoT pHAT provided reliable and fast connections for both WiFi and Bluetooth, which is hardly surprising since it uses the same Broadcom 43438 wireless radio chip used in the Pi 3. The signal strength and quality from the on-board antenna were fine, but can be improved by adding an optional external antenna kit ($9/£7) if needed. As the pHAT only uses 15 GPIO pins and leaves 11 free, including the I²C and SPI pins (see **magpi.cc/2ckXvYH** for details), it's possible to stack it on top of most other add-on boards, such as the Enviro pHAT or Analog Zero, equipped with an extra-long stacking header.

Last word

The IoT pHAT is a neat and convenient way to add WiFi and Bluetooth connectivity to your Pi Zero, while freeing up the data port. Using the same wireless radio chip as the Pi 3 results in reliable signal strength and quality via an on-board or optional external antenna.

★★★★☆

Related

OFFICIAL WIFI DONGLE

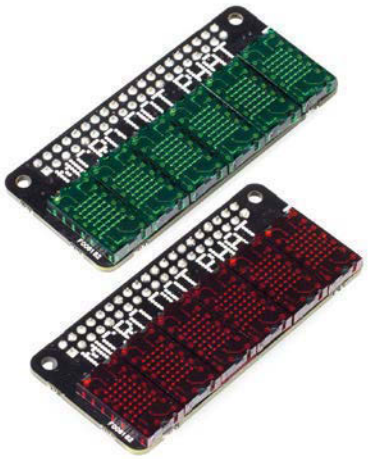
You'll need a USB OTG adapter to plug it into the Pi Zero, but it provides reliable WiFi connectivity, though not Bluetooth.

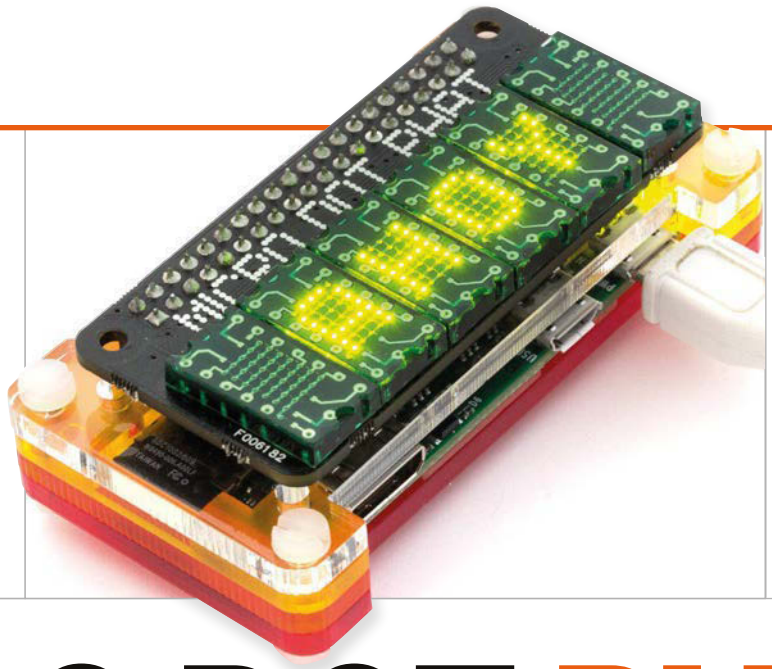
£6 / $8

magpi.cc/2cl1btk

magpi.cc/2cfq70b

£22 / $29





Maker Says

"An unashamedly old-school LED matrix display board"

Pimoroni

MICRO DOT PHAT

A versatile mini LED display with retro appeal

The LTP-305 LED matrices used with the Micro Dot pHAT boast a substantial heritage, having been introduced in 1971 by Texas Instruments. Now manufactured by Lite-On, they come in green and red varieties and feature 5×7 pixels plus a decimal point. Up to six can be mounted on the Micro Dot pHAT, included in the full kit (£22) or purchased separately for £5 per pair (the bare pHAT is just £8), so you could opt for fewer to suit your project's needs. You'll need to warm that soldering iron up, as the full set requires connecting 118 pins: 13 each for the matrices, plus a standard 40-pin female header. Since each matrix has a leg missing on one side, mirrored on the board, there's no chance of accidentally inverting them. You'll want to ensure they're sitting flush, though.

With the soldering done, it's simply a matter of installing the software with a single terminal command. This loads the Micro Dot's own Python library, plus optional example scripts, although for some reason we ended up having to download them manually. Running the **flash.py** script is recommended first, to check all the pixels are working. Other code examples demonstrate the display's considerable capabilities and possible uses, including an excellent digital clock, animated bar graph, sine wave, and scrolling text – horizontal and vertical. The comprehensive Python library enables you to light individual pixels; it also includes options to alter brightness to fade text in and out, and use a tiny text mode to write smaller characters, rotated 90°.

While the display's high number of small pixels results in well-defined digits and letters, which look excellent when shown one per matrix, horizontally scrolling text isn't quite so easily read due to the gaps between matrices. Other than that, however, this is a very versatile retro-style display and certainly a cut above the standard seven-segment alternative. And since each pair of matrices is driven by an IS31FL3730 chip, talking to the Pi via I²C on addresses 0x61, 0x62, and 0x63, you should be able to use the display alongside many other boards, such as the Enviro pHAT.

Last word

Apart from the slight difficulty in reading horizontally scrolling text due to the gaps between matrices, this is an excellent, highly versatile retro-style LED display. Superior to seven-segment LED displays, it renders characters in great detail and could come in useful for all manner of projects. You might even be able to play simple games on it, like Pong.

★★★★☆

Related

SCROLL PHAT

While not quite so fancy, this all-in-one 11×5 array of white LEDs is easier to assemble and ideal for scrolling text.

£10 / $13

magpi.cc/2c38LH3

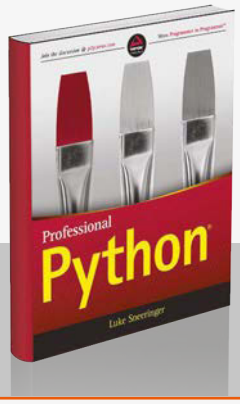
RASPBERRY PI BESTSELLERS

WROX PROFESSIONAL

Take your nascent coding skills up to the professional level with Wrox's popular Professional Guides.

PROFESSIONAL PYTHON

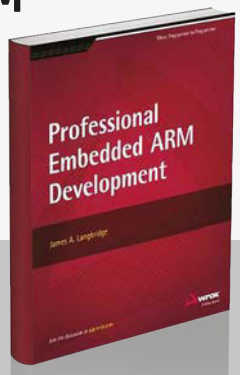
Author: Luke Sneeringer
Publisher: Wrox
Price: £33.99
ISBN: 978-1119070856
magpi.cc/2cCfozG



One of the best intermediate Python books – this one really fills the gaps in your knowledge after your first tutorials and projects. Read the full review in issue 42.

PROFESSIONAL EMBEDDED ARM DEVELOPMENT

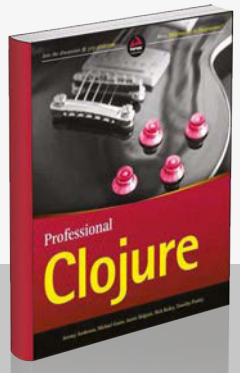
Authors: James A Langbridge
Publisher: Wrox
Price: £33.99
ISBN: 978-1118788943
magpi.cc/2cCfJm8



A comprehensive introduction to Assembly language development on ARM-based boards like the Raspberry Pi, with plenty of background and information on essential tooling, though lacking updates on most recent processors.

PROFESSIONAL CLOJURE

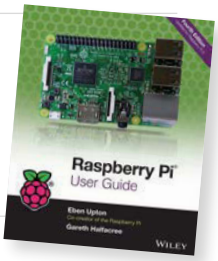
Authors: Jeremy Anderson, Michael Gaare, Justin Holguín, Timothy Pratley & Nick Bailey
Publisher: Wrox
Price: £33.99
ISBN: 978-1119267270
magpi.cc/2cCf3gz



A book that makes you think, from the first chapter's dive into thoughtful code-led examples, and covers web services, testing, and performance. Brings you closer to functional thinking.

RASPBERRY PI USER GUIDE

Author: Eben Upton & Gareth Halfacree
Publisher: Wiley
Price: £16.99
ISBN: 978-1119264361
magpi.cc/2cCfdoi



The unofficial 'official' guide reaches a fourth edition, reflecting the rapid pace of Raspberry Pi development, but remains focused on the opportunity to learn the creative act of programming. Given that aim, the bare-bones board needs a manual, particularly for users and families with little experience of GNU/Linux, coding, or physical computing.

Part I, The Board, will get you started; there's chapters on the range of boards, connecting up, using Linux, troubleshooting (with its own chapter, as befits a serious manual), network configuration, the config tool, and advanced configuration. Only parts of this will be needed by most users, but when you do need to dip into this reference, Tip boxes and the occasional warning combine with clear listings and tables, and just enough screenshots, to help anyone get up and running.

The chapter on setting up a web server has been dropped – possibly reflecting both the diversity of web server options and the simplicity of setting up common configurations – but media centre and productivity chapters remain. The short programming chapters (Scratch, Python, Minecraft) are model introductions, with good pointers to further reading. Hardware and physical computing round off a reference which will become as essential as its three predecessors.

Score ★★★★☆

ELECTRONICS FOR KIDS

Author: Øyvind Nydal Dahl
Publisher: No Starch
Price: £17.99
ISBN: 978-1593277253
magpi.cc/2cCf7wN

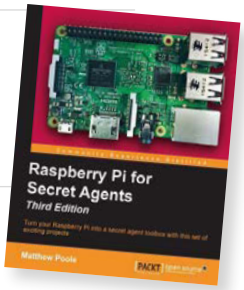
Looking for a book which teaches electronics practically through projects, without neglecting the theory and component knowledge, and does it in a way that will keep young readers interested, without talking down to them? Here it is. In the introduction, Joe Grand talks about the "hacker mindset – solving problems with unconventional solutions, pushing the limits of technology, harming no one, and learning through constant questioning and experimentation." This book will help children to embrace that curiosity.

Its clear and logical progression gives a good grounding in the basics of electronics, reinforced through practical projects. Clear diagrams throughout complement a text full of explanations and project-based learning. The first project, an intruder alarm for your room, is delightfully hands-on, with an aluminium foil strip on the door and a guitar string as trigger wire. Each project features a troubleshooting section.

Electromagnets, motors, shake generators, fruit batteries, destroying an LED, flashing a light, soldering, a transistor-based touch switch, and a sunrise wake-up alarm: these short projects lead you through discrete electronics. Then it explores integrated circuits with 555 timer-based musical projects, digital electronics with simple games, and a great introduction to logic gates and memory circuits, culminating in a reaction game. Enlightening and fun.

Score ★★★★★

RASPBERRY PI FOR SECRET AGENTS



Author: Matthew Poole
Publisher: Packt
Price: £23.99
ISBN: 978-1786463548
magpi.cc/2cCfOWM

Learning by doing goes even better when fun and motivation combine in mini-projects: here the projects are spy gadgets or simple pranks, and this update over the previous edition (reviewed in issue 32) adds in the miniaturised Pi Zero for even better gadgets, as well as the Pi 3. It's an interesting collection of projects, which reaches areas of Linux and computing not touched upon by many similar titles.

The first chapter introduces the Pi and setting up, but jumping to chapter 2 for the audio projects there you get an introduction to the Linux sound architecture, and then using its components for a number of pranks in bite-size projects. Video follows, both with the Pi Camera and controlling a TV through the HDMI interface. Then the Pi goes 'off-road' with some "stealthy reconnaissance missions".

From radio jamming to tracking the Pi, projects are fairly software-centric, and therefore require little in the way of other components until the final chapter's GPIO-based projects, including a laser trip wire and an LED matrix to display secret messages. Along the way, readers can pick up tips about real random number generation, along with useful ways of connecting the Pi to the world, like SMS gateways.

Score ★★★★☆

CREATING BLOGS WITH JEKYLL

Author: Vikram Dhillon
Publisher: Apress
Price: £27.99
ISBN: 978-1484214657
magpi.cc/2cCeUcO

If you're fed up with WordPress plugin problems and slow page loads, you've probably thought about a static blog. Static blogging, with its philosophy of leveraging your coding knowledge and letting almost nothing get in the way of the writing, is a great way of getting back control of your publication platform. This book is about much more than simply setting up a static blog, starting with somewhat laboured chapters of background on how the internet got where it is, but it contains useful material of real interest.

Jekyll's competitors, including the Python-powered Pelican, get a fair examination, and technologies necessary for static blogging – Markdown, Git, and styling tools like Bootstrap, Foundation, SASS, and LESS – are introduced, before Jekyll itself is installed and examined in a concise roundup.

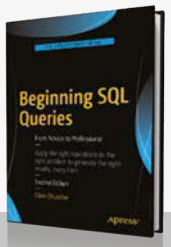
The Projects section presents interesting use cases which walk through the practicalities in a more applied way and, after skimming earlier sections, are probably where most readers will spend their time. This section combines the practical (tags, Git, theming, Mailchimp, gem, Bundler, etc.) with food for thought on platforms for open debate, open research, and open healthcare. Walk through the examples to gain a real appreciation of Jekyll's potential.

Score ★★★★☆

ESSENTIAL READING: SQL

Relational databases remain the essential but unglamorous workhorses behind the Web of Things

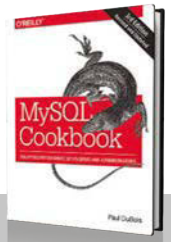
Beginning SQL Queries: From Novice to Professional



Author: Clare Churcher
Publisher: Apress
Price: £19.99
ISBN: 978-1484219546
magpi.cc/2cCgwmY

Great coverage of all the key topics in querying SQL databases, in a reasonably beginner-friendly style.

MySQL Cookbook



Author: Paul DuBois
Publisher: O'Reilly
Price: £56.99
ISBN: 978-1449374020
magpi.cc/2cCfpUt

DuBois gives the right balance between great examples and clear explanations of the theory behind them.

Introduction to Databases

Author: Jennifer Widom
Publisher: Stanford OpenEdX
Price: Free
ISBN: N/A
magpi.cc/2cCh3Fu

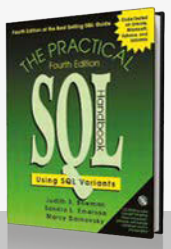
One of Stanford's three inaugural MOOCs, now split into self-paced 'mini-courses', covering different aspects of databases.

PostgreSQL Server Programming

Author: Usama Dar, Hannu Krosing, Jim Mlodgenski & Kirk Roybal
Publisher: Packt
Price: £30.99
ISBN: 978-1783980581
magpi.cc/2cCguLO

Very good guide to working with PostgreSQL in Python, Perl, Tcl, C, and C++, as well as PLpgSQL.

The Practical SQL Handbook



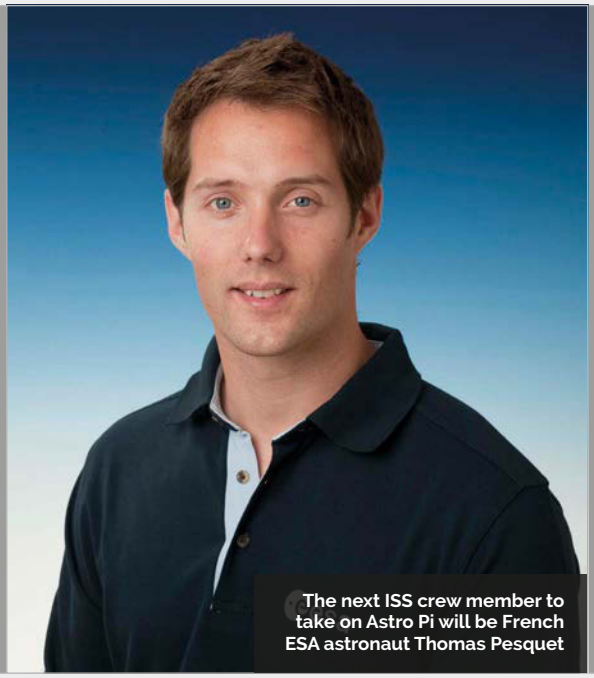
Author: Sandra L Emerson, Judith S Bowman & Marcy Darnovsky
Publisher: Addison Wesley
Price: £43.99
ISBN: 978-0201703092
magpi.cc/2cCg1tk

This edition – after 15 years in print – remains one of the best SQL references, whatever implementation you use.

THE MONTH IN RASPBERRY PI

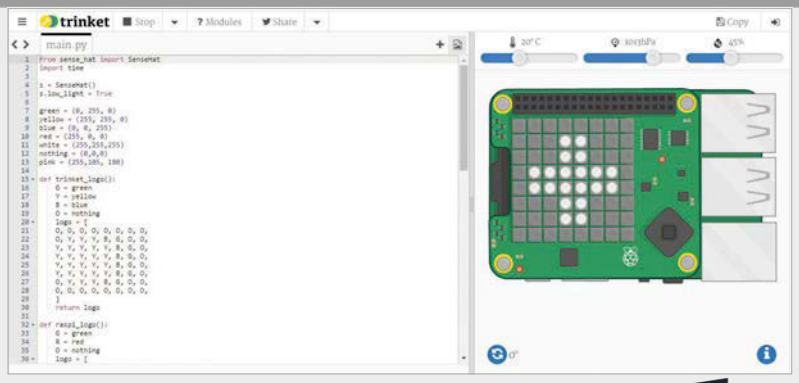
Everything else that happened this month in the world of Raspberry Pi

CREATE YOUR OWN VIRTUAL ASTRO PI



The next ISS crew member to take on Astro Pi will be French ESA astronaut Thomas Pesquet

Image courtesy of the ESA



Above The browser version code can be copied straight into a Python script and used on a Pi with a Sense HAT attached!

As we've said many times, while Tim Peake's mission may be over, Astro Pi lives on.

The next step involving French astronaut Tom Pesquet is gaining steam. One way in which Dave Honess, head of Astro Pi at the Raspberry Pi Foundation, wants to improve participation is by creating a virtual version of the Sense HAT that you can use to program with Python.

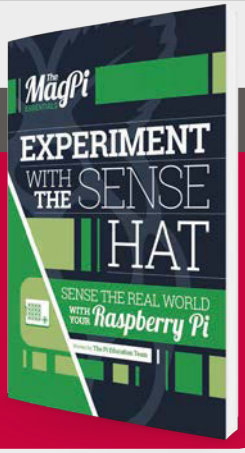
There are two versions: a web-based one that can be used anywhere (**magpi.cc/2cA6bIb**) and a module for Python that you can actually program on the Raspberry Pi (**magpi.cc/2d6vXaa**). This Python module variant also works better with older Raspberry Pis, without needing the extra bit of oomph required to power the web version.

The software allows students to program the Sense HAT without actually owning one and as it's all Python-based, it works exactly the same and allows the code to be loaded onto a Raspberry Pi with a Sense HAT attached, albeit with the line of code to import the relevant module removed.

This means it also works with other projects that bridge the Sense HAT with another piece of software via Python, such as Minecraft. There's no time like the present to start playing with a Sense HAT!

SCIENCE WITH SENSE HAT

Want to find out just what you can do with the Sense HAT? We have an Essentials book just for you – *Experiment with the Sense HAT* takes you from the basic steps, all the way to controlling Minecraft Steve using one. It's available as a free PDF ebook as well as a printed book. Find out more here: magpi.cc/Sense-HAT-book



CROWDFUND THIS!

The best crowdfunding hits this month for you to check out...

UART HAT

kck.st/2cTF1uC

"During development/research for a project which needs more than one UART port, the common replacement for the Raspberry Pi is the Arduino MEGA," the Kickstarter pitch goes. "This is because the MEGA provides four UARTs which can be used at the same time, creating a multi-UART device."

Instead of making that switch and to keep using the Raspberry Pi, Tony Chang has created a series of HATs that can add one, two, or four UARTs to a Raspberry Pi. At the time of writing, it's nearly funded, so maybe you can make the difference?

HUBPIWI BLUE

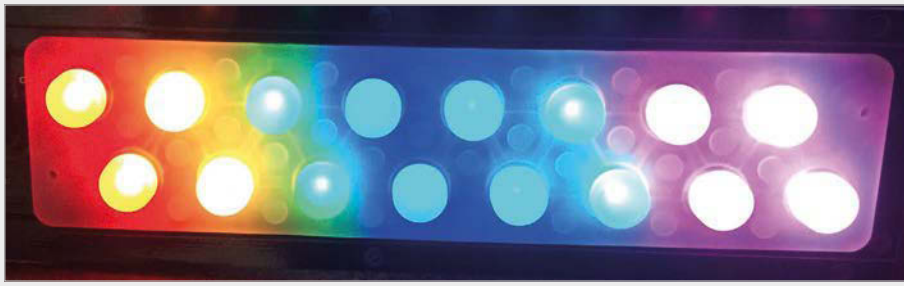
kck.st/2bsXrEw

What the Raspberry Pi Zero does for its size and price is absolutely amazing. The HubPiWi Blue (say that three times fast) offers to make it even better with a diminutive HAT that adds an extra few USB ports, along with a wireless LAN and Bluetooth radio chip. The USP of the HubPiWi is that you don't need to attach it to the GPIO ports: just screw it to the Pi Zero and it makes contact with the USB and power pads on the circuit board to add the extra features.

COOL BUTTONS

kck.st/2cy2u4f

This is a fun little Kickstarter: Cool Buttons are light-up buttons for hobby electronics projects, just like the kind people make on the Raspberry Pi. Its creator Jessica Kedziora believes the ones she's crowdfunding here are the perfect project buttons: easy to install and with the perfect press feeling to them. They come in pre-arranged strips so you can easily scale 3D-printed control cases for them. Give them a look; they may be the thing your project is needing.



BEST OF THE REST

Here are some other great things we saw this month

magpi.cc/2cA3EOp

WORLD'S SMALLEST MAME ARCADE CABINET

This is amazing. No larger than a Raspberry Pi Zero, this ever so tiny MAME cabinet can play many classic games using tiny buttons and a tiny joystick, all displayed on a 0.96" OLED screen. Fiddly but extremely cute. We want ten (as we'll inevitably lose some).

magpi.cc/2cA4bQe

FIRE PONG

We're reminded of the episode of *Friends* with Fireball, though this has no real balls involved. The aim of the game is to 'bat' back the flame with the correct timing. If you miss, a huge puff of flame goes off. First to three wins. Just don't set yourself on fire.

MOSI MAKEFEST: LEARNING • MAKING • INSPIRING

Video games always seem to interest the younger makers in the audience

MINECRAFT, STEAM, AND PATTERNCRAFT

Minecraft filled MOSI's entrance hall with kids creating and coding. FACT – Liverpool's Foundation for Art and Creative Technology – and digital artist Ross Dalziel filled the place with Raspberry Pis. Every table had kids and families absorbed in using Python, via Martin O'Hanlon's mcpi API, to create 1830s carriages to go with the Liverpool to Manchester railway theme.

Their Pi HAT links sensors from the real world to that of Minecraft; with its own wireless connections, it can be used in schools to bypass locked-down networks, and in other projects. Children also discovered the pleasure of hammer + punch = noise at Gemma May Latham's PatternCraft, a collaboration with STEM ambassador David Whale (the well-known **@WhaleyGeek** on Twitter). This has produced a punch card reader for the Pi, bringing together the links between textiles, code, and Minecraft.

RESOURCES

Adventures in Minecraft: **magpi.cc/2cymqYJ**
By David Whale, Martin O'Hanlon

Minecraft of Things: **magpi.cc/2cyjFGP**

PatternCraft: **magpi.cc/2cylmE7**

How do you get children excited about science, coding, and making? Just take them to a MakeFest for some hands-on fun

MakeFests and Maker Faires, along with other hands-on events that combine Raspberry Pis, fun science, and imaginative hardware projects, are a family-friendly way of trying your hand at a range of skills and, with bit of imagination, seeing what you can produce. The MakeFest at MOSI, Manchester's Museum Of Science and Industry, benefits from a backdrop of historic science and engineering; the event was buzzing with excited children, inspiring projects, and a mellifluous cacophony of mechanical sounds.

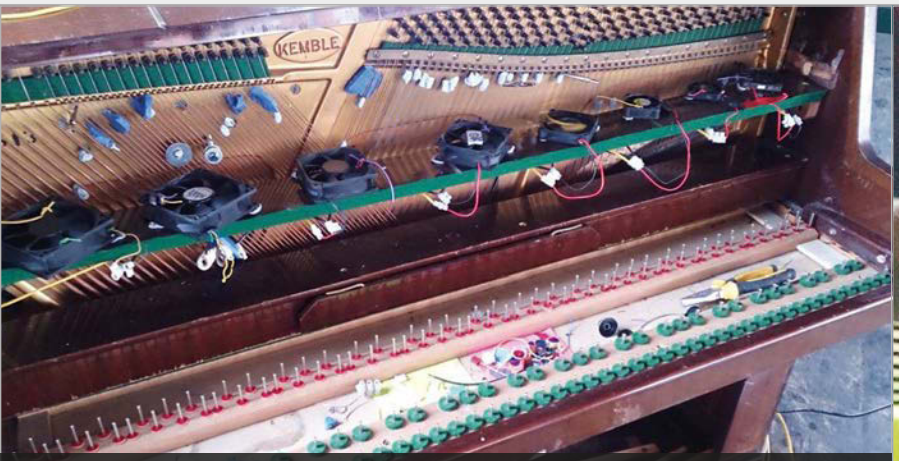
Beneath a giant screen of Minecraft modder Mr Brutal's recreation of the historic 1830s Liverpool to Manchester rail journey was everything from 3D printing demonstrations to potato balancing (food allergy notice: "Potatoes are used in this experiment"). The Raspberry Pi was seen attached to several screens full of Minecraft, but was also quietly keeping score on DoES Liverpool's NERF shooting range of MakeInvaders. The 50th anniversary working recreation of Baby, the world's first stored-program computer, filled one end of MOSI's foyer; once again, it was kept company by York Hackspace's Baby emulator, as well as their "game of co-operative shouting", the Pi-powered SpaceHack [see *The MagPi* #39]. The soundtrack of the room was an anvil chorus of hammering at PatternCraft.

Making sounds

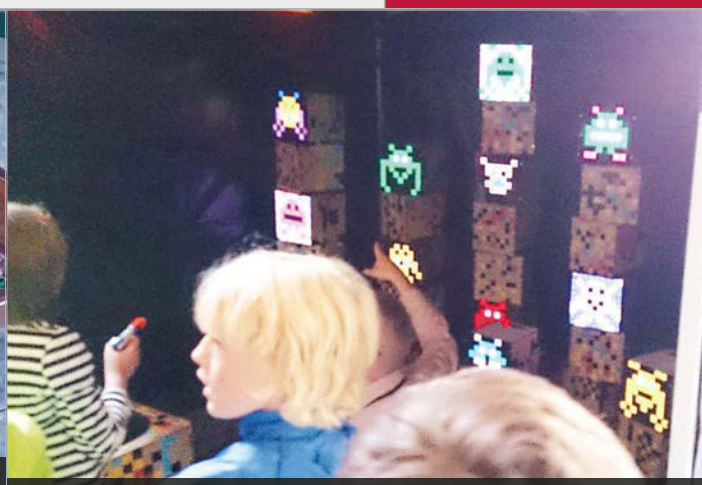
Another MOSI replica ran outside: Robert Stephenson's 1830 Planet, the first steam locomotive to employ inside cylinders. Inside the station building you could make your own planet from Plasticine, and Bolton-based community enterprise Brightmet Long Arm Quilting Studio appealed to all ages with plenty of tactile materials and colourful acrylic paint, to produce printed fabric pieces to take away. Between them, The Hive's Pi-based pop-up coding studio had Python and Scratch introductions.

Making a musical instrument involves a long apprenticeship, but deconstructing one is something all makers can try! Noisy Toys, a star of last year's MakeFest [see *The MagPi* #38], used wires attached to CPU fans to pluck piano strings; the sound was fed through the modulators of an old synth. Throughout the weekend, you could help to build and code a string section for the Manchester Robot Orchestra; to hear the completed orchestra, look for announcements on the **@robotsmcr** Twitter feed.

For lower-tech instruments, Musical Carrots were constructed from hollowed out root vegetables, a paper 'reed', and an elastic band. The glove-a-phone, 'bagpipes' made from a length of plastic plumbing pipe and a surgical glove, was demonstrated against the backdrop of the mighty industrial engines in MOSI's Power Hall, while *The MagPi* watched a team of



Noisy Toys hooked hardware to piano strings and processed the sounds through analogue synth boards for intriguing new tones


There were a lot of kids getting involved at the MakeFest

volunteers training young people aged 12 and up to solder, making a flashing light badge. Nearby were laser cutter demonstrations with wooden robots, people making metal detectors, a micro:bit robot which responded to hand claps, and CodeBug workshops for children as young as five, as well as K'NEX models of steam engines and some old-school Meccano models.

Hack Oldham's work with Age UK training kids in these traditional skills through cross-generational workshops, and talked about the "create, don't consume" ethos which unites all of the diverse community of makers found at the event. With a chance to make textile art, try embroidery, and hand-stitch (and re-engineer) toys, some families spent hours here.

> "Nearby, everything from LEGO to plastic figures was repurposed and motorised by John Walton"

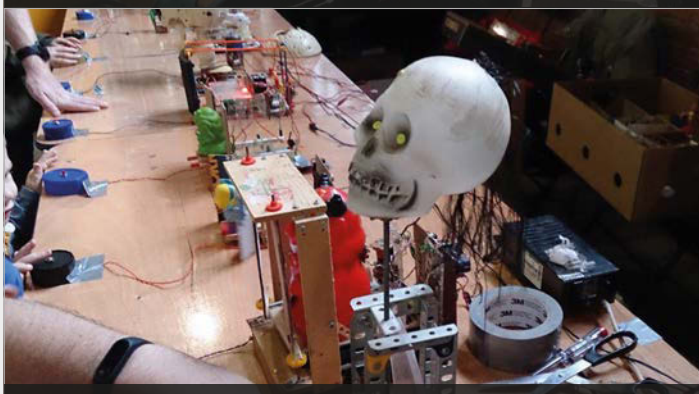
The fabric of makers

In the Textiles gallery, clustered around the cotton looms of the industrial revolution cranked into rather noisy life by museum staff, several MakerSpaces were demonstrating their spin on some of humanity's oldest technologies with threads and fabrics. Weaving your own phone case on the Lancaster And Morecambe Makers (LAMM) table was an ideal introduction to the pre-industrial version of what was seen at scale in the MOSI displays.

Hack Oldham's Mike Healy told *The MagPi*: "People have a perception of making as all about digital and physical computing, but traditional skills are just as important: the maker community is about *skills*." Mike told us about

Nearby, everything from LEGO to plastic figures was repurposed and motorised by John Walton, and no one could walk past his Toy Hacker stall without pressing a button to make one of the toys come to life. Next door was another stack of Pis on the Exa Foundation's stall. There, Alan Donohoe of Raspberry Jam fame used Monk Makes kits, Python, Minecraft, and an inexhaustible supply of handy metaphors, and spent a busy weekend introducing families to coding and physical computing. In this, he was ably assisted by 16-year-old Louis, a veteran of many Raspberry Jam events who has a real passion for computing. If there's a maker event coming up near you, don't miss the chance to take your family and inspire the next generation.

FACT's digital artists created the Minecraft of Things with eager young Python programmers

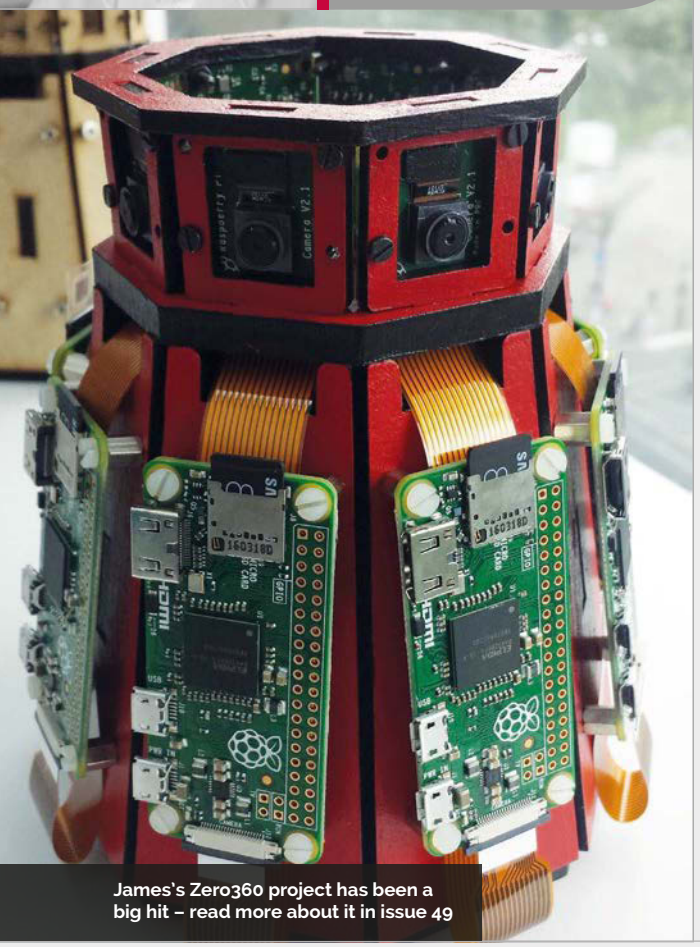

Moving melanges of motorised toys make an irresistible button press

MakeFest provided plenty of quirky fun – who knew you could make a clarinet out of a carrot?

BERLIN RASPBERRY JAM: AN INTERVIEW WITH **JAMES MITCHELL**

JAMES MITCHELL

A Scottish-born, Berlin-based, software quality assurance engineer, he's the organiser of the Raspberry Jam Berlin running for the last two years.



James's Zero360 project has been a big hit – read more about it in issue 49

Practical tips for setting up a Raspberry Jam from **James Mitchell**, a Scot living in Berlin

We catch up with James Mitchell, a face you may recognise from the pages of *The MagPi*, about the Raspberry Jams he stages in Berlin.

How did you find out about Raspberry Pi?

"I had been following the Raspberry Pi since the first BBC news report showing the prototype. At the time, I was looking for an affordable solution to learn Linux without having to reinstall my laptop's operating system. You could say it was love at first sight.

"After owning a Raspberry Pi for a few months, I started to search like others do for tips, tricks, and tutorials online. It's then I started to notice Raspberry Jams being set up all over the UK. We didn't have these events in Berlin, so I decided to start a Jam of my own. Thankfully, I had loads of support from Jam leaders, and even got the chance to meet Ben Nuttall when he visited Berlin shortly before he joined the Foundation. He was a great inspiration!

"After getting started with the Jam, lots of things started to fall into place. I started to build a lot more projects mainly using the Pi camera; I have a little obsession with photography and I'm particularly fond of time-lapse. My kids also started to get involved with the Raspberry Pi. They're still a little young yet, but I love that they stay enthusiastic."

Why did you decide to start the Berlin Raspberry Jam?

"It really was the lack of events in and around Berlin that got me going. I really wanted to attend one of the UK Jams, as it seemed full of like-minded people willing to help each other and learn new things, something we sorely lacked here.

"I did later manage to attend the Raspberry Pi Birthday Parties in Cambridge. While considerably larger than most Jams I've heard about, it was totally amazing to meet the community and it reinforced the sense of belonging I had been looking for.

"On 5 July 2014, I held the first Raspberry Jam Berlin in a co-working office that offered their space on the weekends for free if you didn't charge for tickets. I had some Pis set up with various

James opens the Berlin Jam with a welcome talk

add-on boards and we also had a few talks about the Raspberry Pi.

"The first Jam had some talks about how to use the Raspberry Pi, others highlighting certain add-on boards, and a talk about installing Flask. I also had some workstations set up so people that didn't have a Pi could just take a look and see what it's all about.

My favourite thing about Raspberry Jam is meeting different people and seeing those projects that are getting pushed beyond my own understanding. Also, being able to help new people get interested in the Raspberry Pi is rewarding. It's very satisfying to know someone has left the Jam inspired!"

> "Find your like-minded corner of the community and, with their help, expand if you want"

Later, we got robots and project show-and-tells.

"The Berlin Jam does alright – on average, 25 people – but I had found that in summer months there are a lot fewer people attending. I guess they tend to be on holiday or would rather enjoy the awesome Berlin summer weather.

"It does get a little stressful when you have low numbers, but the key is to ignore the numbers and just enjoy the moment. If one person shows up and they walk away inspired, it's a job well done.

What advice would you have for someone setting up a Jam in their area?

"Start small and have a clear idea of what you want from your Jam. Invite a few friends and maybe the local school's computing teacher. Find your like-minded corner of the community and, with their help, expand if you want.

"Don't be intimidated by the size of other Jams. They come in all shapes and sizes and some can be really large. Just keep in mind you're in it to have fun!"

SETTING UP YOUR OWN JAM: JAMES'S TOP TIPS

01. GET HELP:

It's OK to start things off on your own, but it can get quite overwhelming when you get to an event with over 15-20 people. Make sure you have someone around who is willing to take tasks from you.

02. COMMUNICATION IS KEY:

Make sure you get out there and communicate with your little part of the community. If they don't know what's going on, they won't be able to attend your Jam. Give dates well in advance and if you need help, make sure your community knows. You never know who's willing to help.

03. KEEP SOCIAL:

It still amazes me how effective social media is in bringing new faces to my Jam. Really keep tabs on your accounts and keep them up to date.

04. DON'T FORGET TO HAVE FUN:

It's easy to get lost in all the items you have to take care of for a Jam. Make sure you make time for your own projects, too.

RASPBERRY JAM EVENT CALENDAR

Find out what community-organised, Raspberry Pi-themed events are happening near you...

PUT YOUR EVENT ON THE MAP

Want to add your get-together? List it here:

raspberrypi.org/jam/add

FIND OUT ABOUT JAMS

Want a Raspberry Jam in your area? Want to start one? Email Ben Nuttall about it:

ben@raspberrypi.org

HIGHLIGHTED EVENTS

1 EAST LONDON RASPBERRY JAM

When: Saturday 22 October
Where: Barking Library, Barking, UK
magpi.cc/2ci9Mdd
A four-hour event for those who like programming, coding, and technology. Learn how to program Minecraft and GPIO Zero.

2 RAYLEIGH RASPBERRY JAM

When: Saturday 22 October
Where: Rayleigh Library, Rayleigh, UK
magpi.cc/2cvTiBf
See projects from Rayleigh Library Code Club and get a hand with programming your own stuff.

3 NEWHAVEN RASPBERRY JAM

When: Sunday 23 October
Where: Hillcrest Community Centre, Newhaven, UK
magpi.cc/2cvTGjn
An event for people who want to get their hands on and try out the Raspberry Pi, while seeing some great projects.

4 RAIDER RASPBERRY JAM

When: Saturday 5 November
Where: WJ Keenan High School, Columbia, SC, USA
magpi.cc/2cvURzs
An event that will bring students, teachers, makers, hobbyists, and others together to learn about the Raspberry Pi.

REGULAR EVENTS

5 RASPBERRY JAM PRESTON

When: Monday 3 October
Where: Media Innovation Studio, Preston, UK
magpi.cc/2bmQZfA
Learn, create, and share the potential of the Raspberry Pi at a family-friendly event.

6 RASPBERRY JAM LEEDS

When: Wendesday 5 October
Where: Swallow Hill Community College, Leeds, UK
magpi.cc/2bmQXEI
Everyone is invited for a couple of hours of computing fun, talks, demonstrations, and hands-on workshops.

JAM HEAT MAP

7 TORBAY TECH JAM

When: Saturday 8 October
Where: Paignton Library and Information Centre, Paignton, UK
magpi.cc/2ci8aQx
A fun, informal, and family-friendly event that aims to inspire people to get into code and take up STEM subjects.

8 12TH EGHAM RASPBERRY JAM

When: Sunday 16 October
Where: Gartner UK HQ – The Glanty, Staines-upon-Thames, UK
magpi.cc/2ci9rH6
The theme of this Raspberry Jam is Winter Fun – think Halloween, Bonfire Night, and cold weather!

FILL IN THE GAPS!

SCOTLAND NEEDS RASPBERRY JAMS

Raspberry Pi community manager Ben Nuttall would like you to help us spread Raspberry Jams around the country; one area that could do with more is Scotland. If you're handy with a Raspberry Pi and know others who are, why not start your own Jam? If you're keen, email **ben@raspberrypi.org** about it and see page 87 for some top tips on how to get started.

The Glasgow Raspberry Pi Day was great – let's get more Jams in Scotland!

COMMUNITY PROFILE

TIM RICHARDSON & MICHAEL HORNE

Tim and Michael are the guys responsible for the Cambridge Raspberry Jam, CamJam kits, and the Birthday Bash extravaganzas!

Tim & Michael

Names: Tim Richardson & Michael Horne

Category: Event organisers

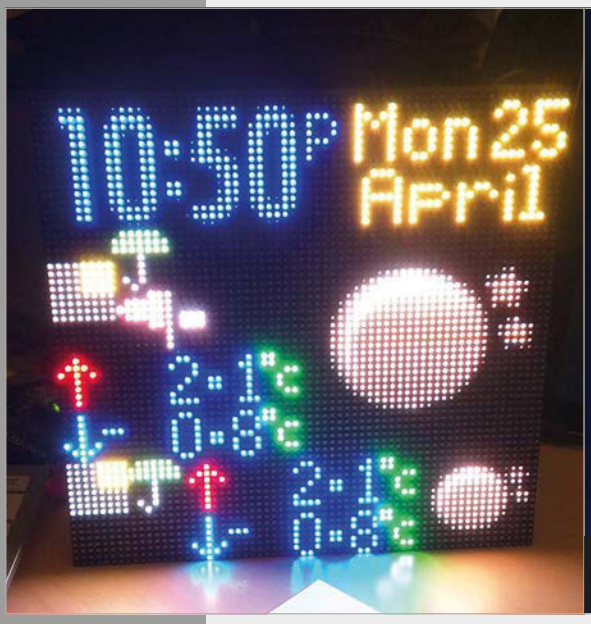
Day job: Michael is a web developer while Tim works as a performance architect.

Website: camjam.me
@Geeky_Tim
@recantha

Michael Horne and Tim Richardson have become regular faces within the Raspberry Pi community, and with good reason. For those local to the Cambridge area, the pair are best known for running for the city's Raspberry Jam – The CamJam – as well as events such as the Birthday Bash and the successful Pi Wars, the next instalment of which is due in April 2017. They're also responsible for many photos and videos you'll have seen on our blog over the years.

Those further afield may have found themself in possession of a CamJam EduKit from The Pi Hut. Available in several varieties, and accompanied by educational resources on the CamJam website, EduKits provide the components necessary for newcomers to the Raspberry Pi to understand physical computing. From sensors to traffic light LEDs, the affordable kits offer everyone the chance to get to grips with digital making, regardless of their skills or experience.

And if that's not enough, the online presence of Tim and Michael continues to permeate the social platforms of the Raspberry Pi Foundation. Both are active within the Twittersphere: you'll no doubt have shared a joke or received advice from either **@Geeky_Tim** or **@recantha**. And if you happen to look for information or updates



Below Tim is most proud of this Weather Clock, a swish-looking display of numbers and icons that indicate the date and time, along with both current and forecast weather conditions

Michael's Music Box is his favourite project: it's a kit that fits neatly into his hand, allowing for the playback and distortion of notes through various button presses and dial twists

On 8 September, Michael and Tim demonstrated some of their projects and kits at the #10MillionPi House of Commons celebrations

on Raspberry Pi products, projects, or updates, Michael's website, **recantha.co.uk**, is most likely to be sitting in your browser history.

For the pair, the Raspberry Pi was a subject of interest pre-launch, with both ordering one from the start. Tim, the eager tinkerer, began his Pi journey from delivery day, while Michael admits to letting his collect a little dust before finally diving in. At first, Michael attended the Milton Keynes Raspberry Jam, learning to solder in order to begin work on a project, the Picorder. Having noticed the Cambridge Raspberry Jam would no longer be running in the home town of the Raspberry Pi, and ensuring he wouldn't step on a few toes in the process, Michael decided to launch his own Jam at the Centre for Mathematical Sciences. "It was so badly organised that I hadn't even visited and seen the room beforehand", he admits. "It was just 30 people at that first one!"

> "I wanted to get vendors to the event so people could buy stuff for their Pis"

This lack of organisational skills would soon be remedied by the introduction of Tim Richardson to the mix. Of future events, Tim notes, "With two of us doing the organisation, we were able to do a lot more. I wanted to get vendors to the event so people could buy stuff for their Pis." They also put together workshops and, later, presentations. The workshops in turn led to the creation of the CamJam EduKit, a means for workshop attendees to take components home and continue their builds there. The transition of the kits to The Pi Hut took place in July 2014, allowing for greater variety and fewer nights filling bags on the living room floor.

More recently, the pair joined the Raspberry Pi team in celebration of the #10MillionPi milestone, bringing their projects to the Houses of Parliament to help introduce more to the Raspberry Jam scene. And of their continued future within the community? The much-anticipated Pi Wars will be taking place over the first weekend in April 2017, offering all ages and abilities the chance to put their robotic creations to the test against a series of challenges.

HIGHLIGHTS

PI WARS

piwars.org

The popular robotics competition allows teams of Raspberry Pi enthusiasts to battle head to head in a series of non-destructive challenges. Rolling into its third year, the next Pi Wars is set to run across the first weekend of April 2017.

CAMJAM EDUKIT

CAMJAM & EDUKIT

camjam.me

From a small room at the Centre of Mathematical Sciences to multiple rooms and hundreds of attendees, the Cambridge Raspberry Jam continues to grow within the birth town of the Pi. The EduKit range – providing everyone with the necessary components to learn LED coding, sensors, and more – is available via The Pi Hut.

RASPBERRY PI BIRTHDAY BASH

magpi.cc/2cBFJy0

Cake, project builds, and merriment: the Raspberry Pi Birthday Bash's continued success draws people from across the globe to join the team in celebrating the Raspberry Pi, the community, and the future.

YOUR LETTERS

Above The original 30 issues of *The Magpi* are available for free on both the app and the website, and will be free forever

The MagPi legacy

Hi there MagPi. I live in Australia and I have subscribed via the MagPi iOS app. The ad in *The MagPi* magazine suggests I can access all 30 previous editions, but that doesn't seem to be the case on the iPad. Can you please set me straight: what am I missing?
Damian Jolly

Hi Damian: the ad is referring to the first 30 issues of *The MagPi*. If you scroll down on the main page with all the magazines listed, you'll be able to find these issues and you can just download them. While they're available on the app, you can also get them and every other issue of *The MagPi* absolutely free on our website as PDFs, although the reading experience on tablets and phones is slightly better on the app, we reckon.

Counting the votes

I think it's really great that you have the community involved with voting for the top 20 Raspberry Pi projects for this issue. There's a project missing from the list of 30 I'd have liked to have seen, though. Is there any way we could have another selection of excellent projects and add a few extra ones to it?
Henry Simmons

We had a few people ask us if a project was going to be in the list somewhere; hopefully, any ones you thought should be on there ended up being one of the 50 projects we had in the final list. To be honest, we could probably have another 50 projects in the list that are just as good as the selection already there, but we had to make some tough choices. When will we do it again? Well, maybe watch this space for our 100th issue; no promises, though.

There were a few projects people suggested which were newer and hadn't been in the magazine; if you do have a cool unique project, just drop us a line at **magpi@raspberrypi.org** and we'll have a look at it.

Magic number

Congratulations on the sale of ten million Raspberry Pis! I remember when there was five million last February and how that was still an amazing number. 20 million soon, hopefully! I was just wondering what sort of releases we'd see over the next couple of years now that marvellous milestone has been achieved; will there be a Model 3A? What's happening with the Compute Module 3? It's all very exciting.
Sue H

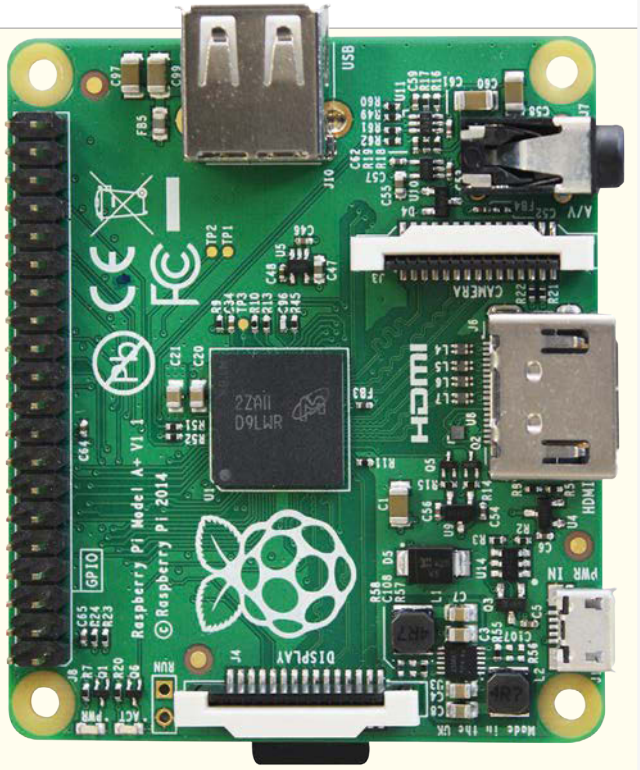
We briefly mentioned it here in the letters section last issue, but the Compute Module 3 is still very much happening. According to Eben, "production orders are in, and we're just waiting for output dates from Sony," so hopefully it will be around in the next few months.

As for the 3A, apparently they're still being planned and haven't gone to production yet. They will be a thing, though! Keep an eye on the Raspberry Pi blog and the magazine for more info for when either are actually out.

New Essentials

I've seen that you have a new range of The MagPi Essentials books, but they're not in print yet. I really love the print versions of the older Essentials books; are you going to be bringing the next set out in print to buy? They go down a storm at my Code Club!
Marie

The printed versions of *Learn to Code with Scratch*, *Hacking and Making with Minecraft*, and *Simple Electronics with GPIO Zero* are on their way! We don't have a set date for them at the moment, but as the last set of printed Essentials books went down so well, we're really looking forward to doing it again.



Above If recent trends continue, the 3A will look a lot like the existing A+

FROM THE FORUM: PIPIN FOR GPIO

The Raspberry Pi Forum is a hotbed of conversations and problem-solving for the community – join in via **raspberrypi.org/forums**

I'm a rank newbie at 60+ years old, and a tech by trade, so I think I can 'get' this stuff.

I saw a program in *The MagPi* a couple of months back – called pipin, I think – which shows the status of the GPIO inputs and outputs. It uses the NPM packaging, but I'm reading all this stuff and it isn't making much sense.

Can someone tell me how to invoke (run) the program? I've installed NPM and pipin, and now I'm lost.

Regards,
Chris M

It looks like pipin was on a Raspberry Pi weekly newsletter rather than the magazine. There's a helpful man page on the NPM website for pipin that should be able to help you out; you can check it out here: **magpi.cc/2cCdu27**.

Some of the useful commands include **`pipin --list`**, which will list all available GPIO options. You can also bring up a schematic with **`pipin --model rpi3`**, specifically for the Pi 3.

As for using it, it looks like you can set different pins to be a particular state (high or low) or read the state of the pin (again, high or low). Look at the man page for more examples; hopefully they will help!

WRITE TO US

Have you got something you'd like to say?
Get in touch via **magpi@raspberrypi.org** or on The MagPi section of the forum at: **raspberrypi.org/forums**

In association with

MODMYPI modmypi.com & osmc.tv

3 OSMC PIDRIVE KITS MUST BE WON!

INTRODUCING THE OSMC PIDRIVE KIT

The stylish OSMC PiDrive keeps your media centre tidy, while maintaining access to all important connectivity. The PiDrive Kit includes the PiDrive case, a Western Digital 314GB hard drive, a SanDisk Class 10 8GB SD card preloaded with OSMC, a 3A power supply, and a Raspberry Pi 3!

ON **WHICH POPULAR** MEDIA **PROJECT IS OSMC** BASED?

Tell us by 24 October for your chance to win!

Simply email **competition@raspberrypi.org** with your name, address, and answer!

Terms & Conditions

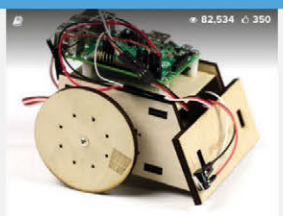
Competition closes 24 October 2016. Prize is offered worldwide to participants aged 18 or over, except employees of the Raspberry Pi Foundation, the prize supplier, their families or friends. Winners will be notified by email after the draw date. By entering the competition, the winner consents to any publicity generated from the competition, in print and online. Participants agree to receive occasional newsletters from The MagPi magazine (unless otherwise stated upon entry). We don't like spam. Participants' details will remain strictly confidential and won't be shared with third parties. Prizes are non-negotiable and no cash alternative will be offered.

hackster.io

500+ RASPBERRY PI PROJECTS

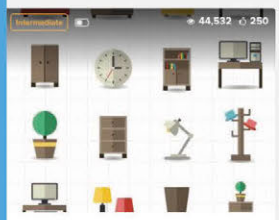
hackster.io/raspberry-pi

Home Automation using Raspberry Pi...
Anurag S. Vasanwala



Robot Kit
Windows IoT

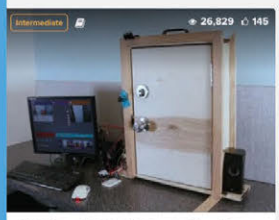
Home Automation (with Raspberry Pi ...
Christian Kratky



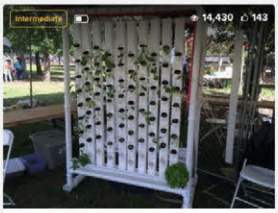
Open Smart Hub : Home Automation
Anthony Ngu

Hands-on-lab IoT Weather Station usi...
Windows IoT

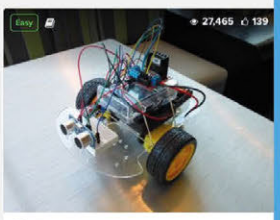
Pi0drone: A $200 smart drone with th...
5 members



Windows IoT: Facial Recognition Door
Team Windows IoT



Vertical Hydroponic Farm
Paul Langdon



Rover
Prasantha Jayakody

MATT RICHARDSON

Matt is Raspberry Pi's US-based product evangelist. Before that, he was co-author of *Getting Started with Raspberry Pi* and a contributing editor at *Make:* magazine.

THE IMPACT OF TEN MILLION

Matt Richardson explains how the first ten million Pis will have lasting effects

Last month, the Raspberry Pi Foundation hit a major milestone by selling its ten millionth computer. Besides taking the opportunity to celebrate – and that we did – it's also a good time to reflect on the impact that the device has had over the last four and a half years. As you may know already, we don't just make an ultra-affordable computer. Our mission is to put the power of digital making into the hands of people all over the world; the Raspberry Pi computer helps us do that.

There are many ways in which the Raspberry Pi has a positive impact on the world. It's used in classrooms, libraries, hackspaces, research laboratories, and within the industrial environment. People of all ages use Raspberry Pi in these contexts and others, to learn about computing and to create things with computers that we never could have imagined.

But I believe the biggest impact we've had was to encourage more people to experiment with computers once again. It used to be that in order to use a computer, you had to have a fairly good working knowledge of how it worked, and often you needed to know how to program it. Since then, computers have become much more mainstream and consumer-friendly. On the one hand, that change has had an incredible impact on our society, giving more people access to the power of computing and the internet. However, there was a trade-off. In order to make computers easier to use, they also became less 'tinker-friendly'.

When I was a kid in the 1980s, our family had an old IBM PC in our basement, that was decommissioned from my father's workplace. On that computer, I learned how to use the DOS prompt to work with files, I created my own menu system out of batch files, and most importantly, I learned my first ever programming language, BASIC.

I feel very lucky that I had access to that computer. That kind of early exposure had such a huge impact on my life. For years I continued to learn programming, both in school and on my own time. Even though I've benefited greatly from the mainstream, consumer-friendly technology that has since become available, I still use and build upon the skills that I learned as a kid on that IBM PC. Programming languages and hardware have changed a lot, but the fundamental concepts of computing have remained mostly the same.

The next generation

I expect that the Raspberry Pi has a very similar impact on young people today. For them, it fills the void that was left when computers became less like programmable machines and more like consumer products. I suspect that, just like with me, this impact will linger for years to come as these young people grow up and enter a workforce that is increasingly dependent on their digital skills. And if even just a tiny bit of interest in computing is the spark, then I believe that a tinker-friendly computer like Raspberry Pi is the kindling.

Here's where that ten million number comes into play. Admittedly, not everyone who is exposed to a Raspberry Pi will be affected by it. But even if you guess conservatively that only a small fraction of all the Raspberry Pis out in the world serve to inspire a young person, it still adds up to an incredible impact on many lives; not just right now, but for many years to come. It's quite possible that many of tomorrow's computer scientists and technology specialists are experimenting with a few of the first ten million Raspberry Pis right now.

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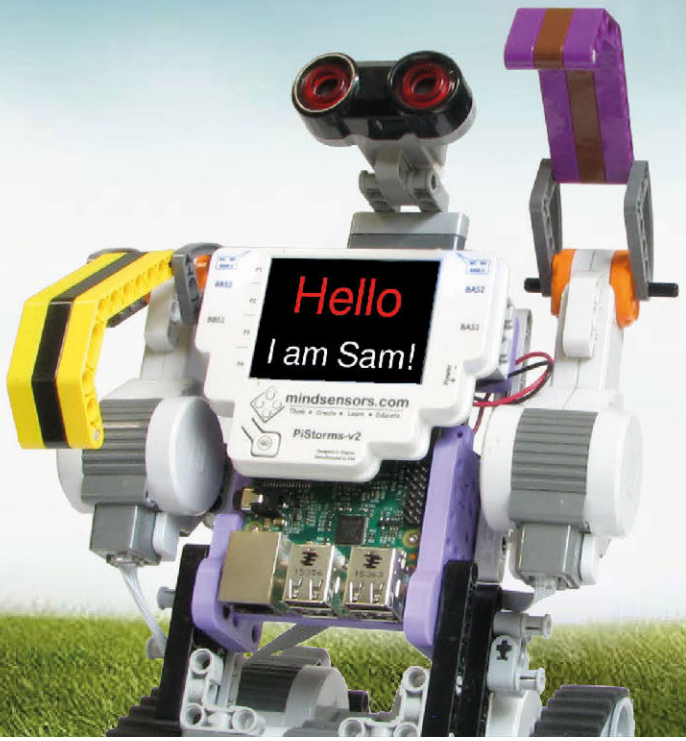

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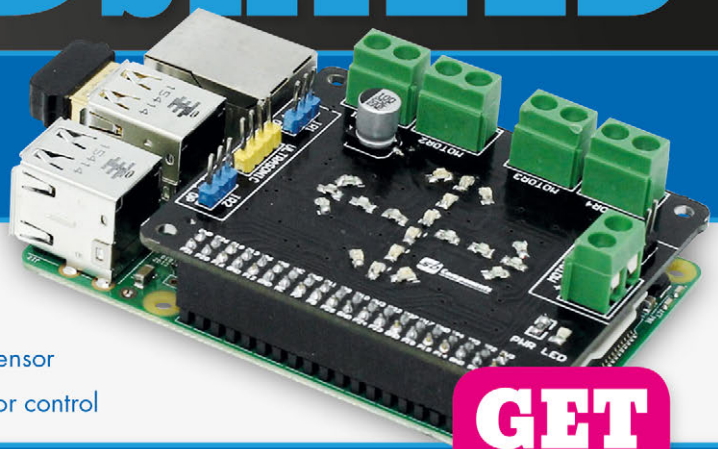

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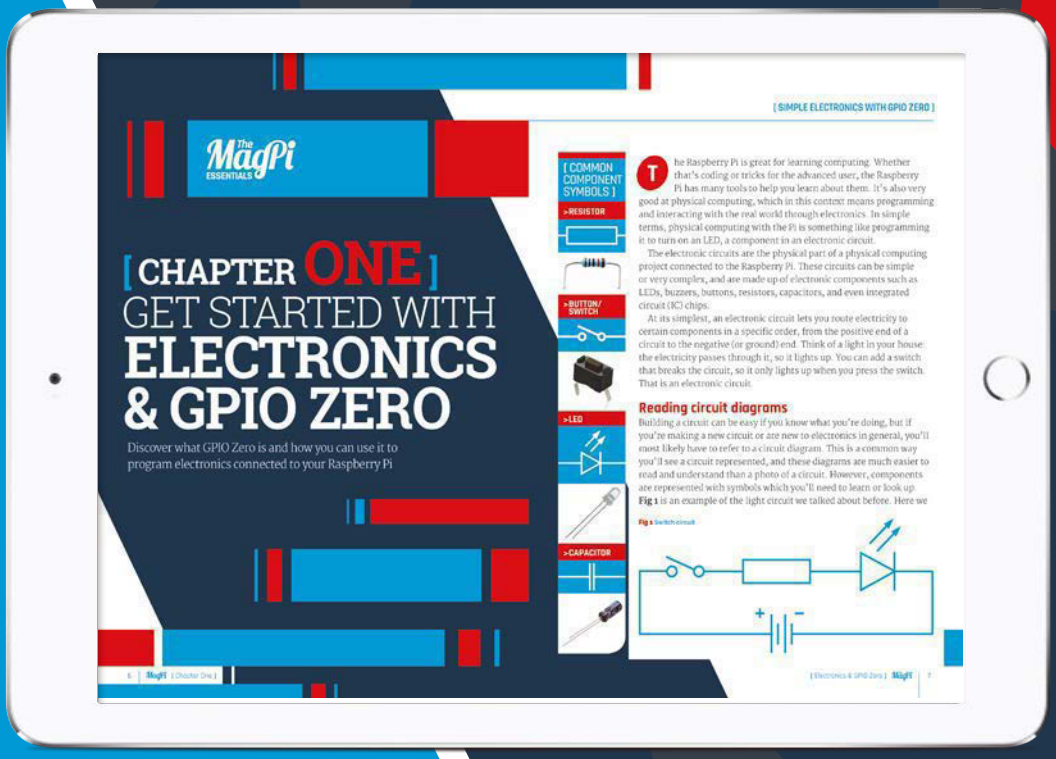
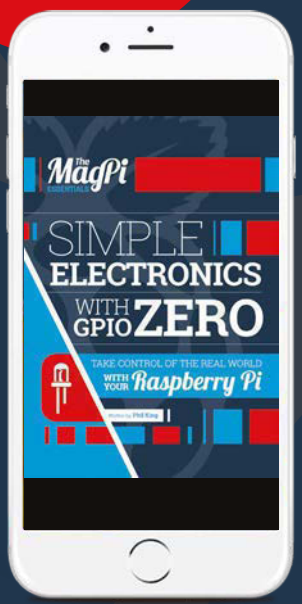

[SIMPLE ELECTRONICS WITH GPIO ZERO]
[CHAPTER ONE]
GET STARTED WITH ELECTRONICS & GPIO ZERO
Discover what GPIO Zero is and how you can use it to program electronics connected to your Raspberry Pi
[COMMON COMPONENT SYMBOLS]
>RESISTOR
>BUTTON/ SWITCH
>LED
>CAPACITOR
Reading circuit diagrams



www.Raspberrypi.org/MagPi

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Stackable expansion boards for the Raspberry Pi

Serial Pi Plus

RS232 serial communication board. Control your Raspberry Pi over RS232 or connect to external serial accessories.

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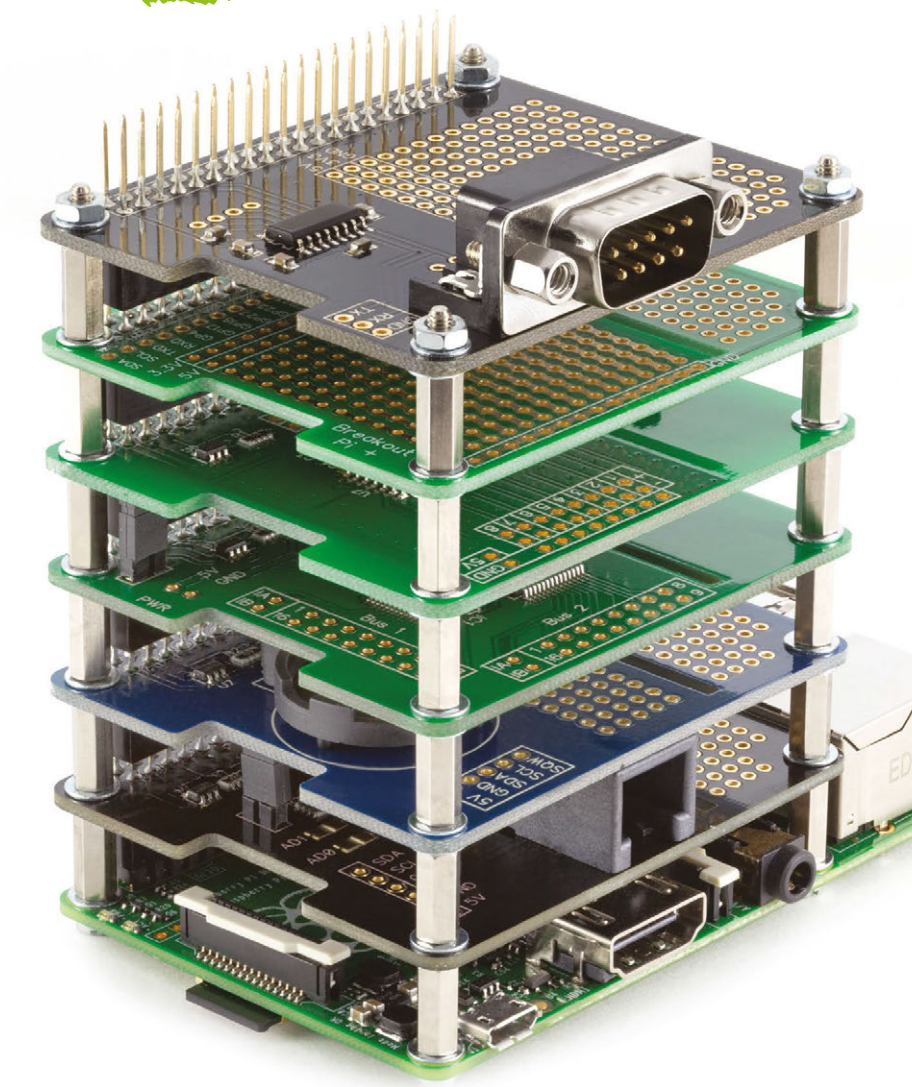
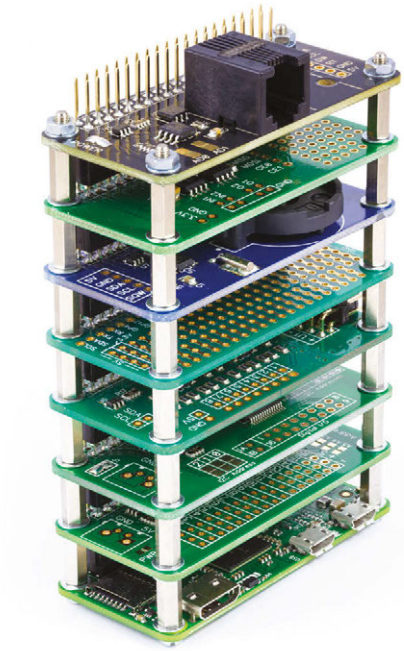
1 Wire Pi Plus

1-Wire® to I²C host interface with ESD protection diode and I²C address selection.



Also available for the **Pi Zero**



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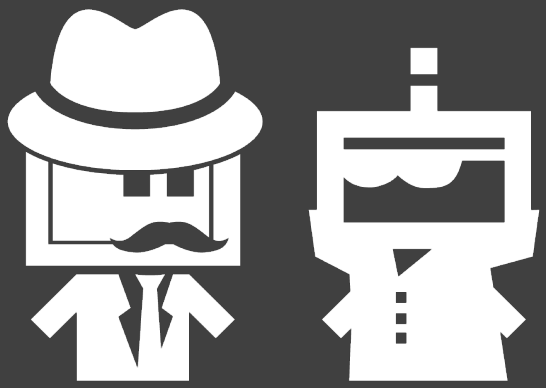

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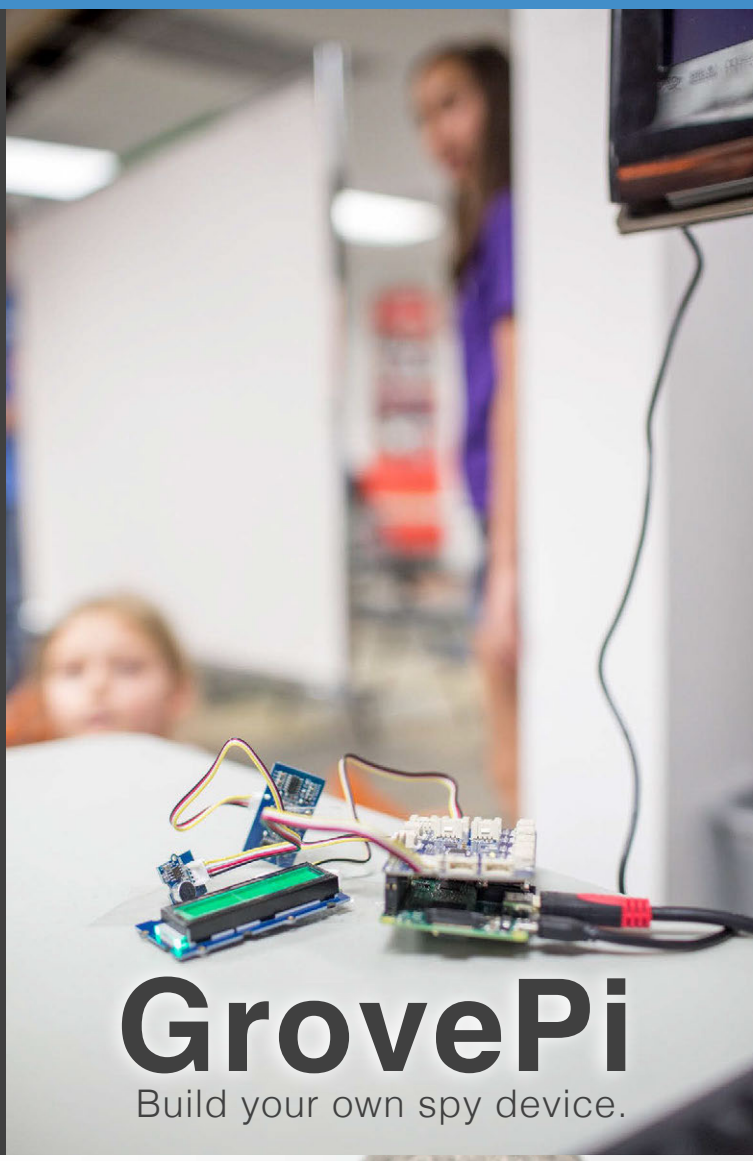

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